Assessing Premorbid Intellectual Abilities in Closed Head Injury: A Comparison of the National Adult Reading Test, Spot the Word and Cambridge Contextual Reading Tests.

by

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DECLARATION

'This thesis has been composed by myself and the work contained herein is my own.'

Kathryn Jane Watt

ABSTRACT

The present study examines the utility of three measures of premorbid intellectual functioning in closed head injury. One of the most fundamental aspects of the clinical neuropsychological evaluation of patients with acquired brain injury is establishing their likely level of functioning prior to the injury. Reliable and meaningful methods for determining premorbid intellectual levels of these patients are essential to aid in the evaluation of intellectual deterioration, in establishing treatment and rehabilitation goals and in resolving medico-legal issues. The most common approach to estimating premorbid intelligence is to use tests of present ability which are considered to be relatively resistant to neurological and psychiatric disorder. Currently, the most commonly used is the National Adult Reading Test (NART) which provides estimates based on the oral pronunciation of irregular words. The Cambridge Contextual Reading Test (CCRT) is a development of the NART where the NART words are set within a semantic and syntactic context. The Spot-the-Word is a test based on lexical decision making whereby a number of parallel routes to perform the task would seem to make it more resistant to the effects of brain damage. The validity of these measures was examined in the current study. A group of 25 head injured subjects was compared with 50 healthy controls and 20 orthopaedic trauma controls. The head-injured group performed significantly worse than the control groups on measures of current intellectual ability, however, no significant differences emerged between the groups on any of the premorbid measures. The CCRT showed the strongest correlation with measures of current intellectual ability and the Spot-the-Word the lowest. Further, depression emerged as a potentially important confounding variable. These results provide supportive evidence for the use of the CCRT in estimating premorbid intellectual functioning in patients who have sustained closed head injury. These implications are discussed and methodological issues highlighted.

1. INTRODUCTION

Neuropsychological assessment of patients with acquired brain injury is critical because such cases are relatively common causes of enduring significant disability. One of the most fundamental aspects of the clinical neuropsychological evaluation of these patients is establishing the patient's likely level of functioning prior to the injury. Although neuropsychological tests are designed to provide precise information about the level of cognitive functioning at a given point in time, test results must be contrasted with the estimated level of functioning before the injury. The discrepancy between current and premorbid level of function is essential in providing an indication of the degree of deterioration as compared to a pre-injury standard. While a low level of performance may reflect either deterioration from a previously high premorbid level or little or no impairment from a pre-existing low level, performance within the average range may indicate a genuine impairment or deficit in the performance of a patient who functioned at a previously much higher level (Baddeley, Emslie & Nimmo-Smith, 1993). Comparing current test performance with an 'individualised comparison standard' (Lezak, 1995) is therefore necessary, however this is a difficult task because often little data exist that provide the basis for direct comparison. Very few patients with brain injury have undergone neuropsychological evaluation prior to the onset of damage or disease, which makes a direct comparison with post-injury testing impossible. Further, simply contrasting a patient's IQ test performance with normative test data are of little value as there are considerable individual differences in intellectual ability in the general population (Crawford, 1992). Clinicians must therefore use indirect methods of assessment whereby present performance is compared with an <u>estimate</u> of the patient's premorbid ability level. Reliable and meaningful methods for determining premorbid intellectual levels of patients with acquired brain injury are therefore essential, and aid in the evaluation of intellectual deterioration, in establishing treatment and rehabilitation goals and in resolving medico-legal issues.

The following sections will consider the epidemiology of traumatic brain injury and the causes and mechanisms of damage which can typically occur. The variety of techniques used in the assessment of premorbid abilities will then be discussed and evaluated before the aims and hypotheses are outlined.

1.1 HEAD INJURY

Head injury is one of the most common types of damage to the brain (Kurtzke, 1984). The more aggressive neurosurgical intensive care of patients with severe traumatic brain lesions has increased the number of victims surviving injuries which would previously have proved fatal (Jennett, 1979). As a result, the cost in terms of human suffering and finance is huge as many of the survivors of head injury are children or young adults whose life expectancy has not been reduced, but who have been left with significant brain damage and permanent disabilities.

1.1.1 Epidemiology

The frequency of head injuries varies considerably between countries. It has been estimated that there are approximately 150 cases of traumatic brain injury requiring hospitalisation per 100,000 of the population in Britain every year (Medical Disability Society, 1988). In the USA, Frankowski, Annegers & Whitman (1985) reported an average incidence figure of approximately 250 per 100,000 of the population in a review of seven major studies. Consistently reported in the literature has been the observation that there is a large peak in the number of cases of traumatic brain injury between the ages of 15 to 24. High incidence rates in the under 5's and in the elderly population have also been reported, with falls being the most common cause of head injury in these two groups (Frankowski, *et al.* 1985: Goldstein & Levin, 1990). In other age groups, road traffic accidents have been found to account for approximately 50% of the cases of head injury, while assaults account for around 25-40% (Kraus, Black & Hessol, 1984). Except in the elderly age group where women outnumber men, traumatic brain injury is two or three times more likely to occur in males than females. It has also been documented that those who sustain head injuries are likely to be unemployed or have a lower socio-economic status or educational level (Naugle, 1990).

High numbers of heavy drinkers have also been found in the head injured population.

1.1.2 Nature and Severity of the Injury

Head injury can be classified into two types, blunt or closed head injury, where the covering of the brain, or dura mater, is not torn and the brain is not exposed and, open head injury, where the skull is penetrated resulting in more focal damage. Closed head injuries are the most common type of head injury (Lezak, 1995). In closed head injury, damage can occur in two stages. Initial or primary damage occurs at the time of impact, while secondary damage is the effect of the physiological processes which occur following the initial injury. *Coup* and *contrecoup* lesions are common primary injuries in closed head injury. There are contusions at the site of impact as the brain is accelerated (*coup*) and brain contusions at the opposite side of the skull as the brain, having accelerated, hits and decelerates against the inside opposite surface (*contrecoup*). These account for specific and localisable behavioural changes that accompany closed head injury (Lezak, 1995). In addition, the cortex of the frontal and temporal poles are particularly susceptible to bruising in patients who sustain such a head injury, typically resulting from a rapid deceleration injury where the brain is pulled over the bony protuberances and ridges on the base of the skull (Pang, 1989). Another type of brain damage occurs when there is rapid acceleration and deceleration along with the rotation of the brain in relation to the head (Pang, 1989). This causes diffuse axonal injury which involves shearing or straining on the delicate nerve fibres within the white matter, resulting in microscopic lesions throughout the brain (Adams, Graham & Gennarelli, 1985). This is a significant factor in loss of consciousness (Parker, 1990). The secondary effects of head injury result from complications subsequent to the initial injury and can cause more diffuse pathology. This can be due to lack of oxygen to the brain caused by damage to other organs; inadequate blood supply to the brain as blood pressure drops; raised intracranial pressure; brain swelling or the development of space-occupying lesions such as haematomas.

The severity of head injuries is vast, ranging from slight bumps that are barely noticed, to those patients who have suffered such severe injury as to leave them comatose for prolonged periods. In closed head injury of any significant severity there is a loss of consciousness. The depth of unconsciousness is often measured on the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974), which assesses functions such as motor responsiveness, verbal responsiveness and eye opening. The best eye opening is rated from 1-4, the best motor response from 1-6 and the best verbal response from 1-5, yielding a score ranging from 3-15. Individuals with a GCS total score of 3-8 are said to have "severe" injuries; 9-12 have "moderate" injuries and those who have a GCS between 13-15 are deemed to have had "mild" injuries. The GCS has been shown to relate to outcome after traumatic brain injury (Jennett & Teasdale, 1981). A further index of the severity of a head injury is the degree of memory loss for events which occurred after the patient has recovered from a period of unconsciousness - the duration of post-traumatic amnesia (Bond, 1990). The duration of post-traumatic amnesia (PTA) is the time from injury to the start of continuous remembering. PTA has been repeatedly shown to be one of the single best predictors of residual problems with cognitive function or functional independence following closed head-injury (Greenwood, 1997), despite the difficulties that have been noted in determining its duration (Jennett, 1972).

1.1.3 Impact of the Injury

Research has shown the diversity and severity of the cognitive deficits (Brooks, 1984), behavioural and emotional problems (Gainotti, 1993; Willer & Linn, 1993) and executive function deficits (Ben-Yishay & Prigatano, 1990) suffered by those who have sustained a closed head injury. In the longer term, such symptoms are far more commonly reported than any physical deficits, are more pervasive and are most likely to be associated with reported stress in relatives (Brooks, Campsie, Symington, Beattie & McKinlay (1987).

Neuropsychological assessment of patients with acquired brain injury is therefore critical because such cases are relatively common causes of enduring significant disability. Assessments are undertaken for a variety of reasons and include:

- describing in detail the consequences of the injury in terms of cognitive functioning and emotional status.
- helping in the estimation of prognosis so that plans can be made for the future.
- planning rehabilitation, placement or return to work on the basis of the patient's strengths, weaknesses and capabilities.
- carrying out medico-legal assessment for litigation purposes.
- monitoring progress or evaluating the effects of treatment by way of serial assessments. (McKinlay & Gray, 1992)

As previously indicated, one of the most fundamental aspects of the clinical neuropsychological evaluation of these patients is establishing the patient's likely level of functioning prior to the injury.

1.2 Assessing Premorbid Intellectual Functioning

A number of different methods of inferring premorbid intellectual levels to use as an individualised comparison standard have been adopted, with varying degrees of success. Historical and observational data are obvious sources of information from which subjective estimates of premorbid ability have been drawn (Eppinger, Craig, Adams, & Parsons, 1987). Estimates based on these methods, however, are dependent on how much is known about the patient's past and may be artificially low (Lezak, 1995). Attempts have been directed towards making these subjective judgements more scientific by developing an objective measure using biographical data which relates to educational and occupational attainments. Such demographic variables are known to be related to IQ test performance (Matarazzo, 1972). Another approach to estimating premorbid intellectual level has been to use tests of current ability thought to be relatively insensitive to neurological and psychiatric disorder.

1.2.1 Tests of Current Ability

Any measure of current intellectual ability must satisfy three basic principles to be suitable as a valid method of estimating premorbid intelligence (Crawford, 1989).

- it must have adequate reliability.
- it must correlate highly with intelligence in the normal population.
- it must, in the main, be insensitive to cerebral dysfunction.

Vocabulary

For many years the most common method for estimating premorbid intelligence from current test performance used a vocabulary score as the single best indicator of original intellectual endowment (Yates, 1954). This arose following observations that many patients with various kinds of organic impairments retained old, well-established verbal skills despite significant deterioration in memory, arithmetic ability, reasoning and other cognitive functions. The Vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955; 1981) has been widely used for this purpose and satisfies the first two criteria necessary for it to be a valid method of estimating premorbid intelligence, namely, it has high reliability and is highly correlated with IQ in the normal population. Indeed, vocabulary has been shown to have the highest split-half reliability of all the subtests of the WAIS and the Wechsler Adult Intelligence Scale-Revised (WAIS-R), with reliability coefficients ranging between 0.94 and 0.96 across all age bands (Wechsler, 1955; 1981). Further, factor analysis of the WAIS and WAIS-R has established that Vocabulary loads highly on the first unrotated factor which is seen to represent *'g'* (general intelligence) and it has also been shown to correlate highly with the WAIS and WAIS-R Full Scale IQ (Matarazzo, 1972).

While the Vocabulary method has been shown to meet the first two criteria necessary to be a valid method of estimating premorbid intelligence, several studies have shown that it does not appear to be very resistant to neurological and psychiatric disorder, with vocabulary performance in these groups being significantly lower than healthy control groups. Hart, Smith & Swash (1986) have shown that control subjects free of neurological disorder and of comparable age and education obtained significantly higher Vocabulary estimated IQ than a group of patients with dementia of the Alzheimer type (DAT). Similar results were shown by Sharpe & O'Carroll (1991). Crawford, Parker & Besson (1988) examined Vocabulary estimated IQ in a variety of organic conditions including closed head injury, alcoholic dementia, DAT, multi-infarct dementia, Korsakoff's and Huntington's Disease. With the exception of the closed head injury group, all clinical groups performed at significantly lower levels than their respective individually matched controls. This suggests that organic disease can impair vocabulary performance and is therefore likely to significantly underestimate premorbid intelligence.

Deterioration Indices

An alternative strategy using similar principles has been to look for differential performance on the subtests of the WAIS. Wechsler devised "deterioration ratios" which were mostly based on the comparison of scores likely to be resistant to the effects of brain damage, with those likely to be susceptible. Tests of previously learned information, vocabulary and other verbal skill scores were seen to be least susceptible - the *"Hold"* tests - while scores on timed tests requiring visuomotor activities were most likely to show the effects of brain damage - the *"Don't Hold"* tests (Lezak, 1995). The "Hold" tests of the WAIS - Vocabulary, Information, Object Assembly and Picture Completion - were compared with the "Don't Hold" tests - Digit Span, Similarities, Digit Symbol and Block Design - in the formula:

$$\frac{\text{Hold - Don't Hold}}{\text{Hold}}$$

The assumption was that an abnormal organic process or early senility would be reflected by a deterioration that exceeded normal limits. A cut-off score providing the suggested indicators of "possible" and "definite deterioration" was calculated, however this deterioration quotient has not been found to be effective in identifying patients with organic damage (Russell, 1972b). Indeed, Larabee, Largen & Levin (1985) discovered that those WAIS subtests regarded as resistant to the effects of organic damage were as vulnerable as those regarded as susceptible. It is apparent, therefore, that approaches such as 'Hold' versus 'Don't Hold' and Vocabulary are notoriously unreliable in providing an accurate estimate of premorbid intellectual levels.

1.2.2 Demographic Variables

In questioning the use of test score formulae for estimating premorbid ability, Wilson, Rosenbaum, Brown, Rourke, Whitman & Grisell (1978) made the first comprehensive effort to systematically combine the demographic variables of age, sex, race, education and occupation into formulae to predict premorbid IQ. These formulae, which are presented below, were generated from multiple regression techniques using the WAIS standardisation sample (n=1,700; Wechsler, 1955) to estimate WAIS Full-Scale, Verbal and Performance IQ.

Predicted Full-Scale IQ = (0.17)Age - (1.53)Sex - (11.33)Race + (2.97) Education + (1.01)Occupation + 74.05

Predicted Verbal IQ = (0.18)Age - (2.02)Sex - (8.99)Race + (3.09) Education + (0.97)Occupation + 70.80

Predicted Performance IQ = (0.14)Age - (0.66)Sex - (12.91)Race + (2.44) Education + (0.91)Occupation + 81.55

The formulae created predicted 54%, 53% and 42% of the variance in WAIS Full-Scale, Verbal and Performance IQ respectively, while education was found to be the single best predictor of IQ. In a follow-up study, Wilson, Rosenbaum, & Brown (1979) found that using demographic variables could improve the accuracy of discriminating between neurological and non-neurological subjects.

There have been contrasting views on the utility of this method, however. Certain studies suggest extreme caution when using demographic approaches.

Klesges, Fisher, Vasey & Pheley (1985) compared the demographically predicted IQ and obtained IQ of normal and brain damaged subjects. Results indicated significant, but low correlations between predicted and actual IQ levels in the normal group. In addition, the demographic equation significantly overestimated obtained IQ. It was therefore concluded that "...we must temper our previous guarded optimism with the adult prediction formulae..." (Klesges *et al*, 1985, p.2). In a further study, Bolter, Veneklasen & Long (1982) examined the relationship between predicted and obtained IQ in head injured patients who were deemed to have "recovered" or who were "still impaired" on the basis of neuropsychological test results. While a reliable and significant relationship was found between demographically estimated IQ and actual IQ, the demographic estimates were not accurate in the individual case, misclassifying the actual IQ in a large proportion of cases. Again, it was concluded that the study had "revealed inadequacies in predicting premorbid IQ's with the Wilson *et al* (1978) equation among head trauma patients" (Bolter *et al.,* 1982, p.173).

It has been proposed, however, that these studies were inappropriate for cross-validation purposes in that they suffered from a number of methodological problems and their samples were composed of clinically referred subjects who were likely to be cognitively impaired (Crawford, 1992). Other more methodologically sound studies have lent support to the method of predicting premorbid IQ from demographic variables. In a cross-validation study, Karzmak, Heaton, Grant & Matthews (1985) found a reasonably close relationship between predicted and obtained Full-Scale IQ in a sample of 491 healthy normal subjects. Further, two-thirds of their subjects' WAIS IQ scores were predicted within a ten-point error margin by the Wilson *et al.* equation. It was at the extremes of the sample that most of the larger prediction errors occurred, with the overprediction of high scores and the underprediction of low ones. Goldstein, Gary & Levin (1986) also found that the 'Wilson formulae' provided "an adequate overall fit" to their data on 69 patients. These results would seem to give credence to the view that the demographic equations are in fact a reasonable predictor of premorbid IQ.

As the 'Wilson formulae' were devised in the United States of America, it has been necessary to develop a set of equations on British demographic data as premorbid measures are only applicable in their country of origin. Indeed, the relationship between demographic variables such as occupation, education or social class and IQ cannot be assumed to be directly comparable in the two countries. To address this issue, Crawford, Stewart, Cochrane, Foulds, Besson, & Parker (1989c) developed demographic regression equations whereby WAIS IQ's were regressed on the demographic variables of age, sex, education and social class, collected from a sample of 151 British subjects without neurological, psychiatric or sensory disabilities. The demographic data provided even less accurate estimates of WAIS scores, predicting 50%, 50% and 30% of the variance in Full-Scale, Verbal and Performance IQ.

Similarly, the 'Wilson formulae' became inappropriate with the revision of the WAIS in 1981 (Wechsler, 1981). Recognising the need for premorbid estimates geared to the WAIS-R, Barona, Reynolds & Chastain (1984) developed new formulae based on those of Wilson *et al.* which incorporated additional demographic variables of geographic region, urban-rural residence and handedness into the equation. Despite these additional variables, the WAIS-R equations predicted only 36%, 38% and 24% of Full-Scale, Verbal and Performance IQ respectively, less of the variance in IQ than the equations based on the WAIS. In addition, the authors note that "where the premorbid Full Scale IQ was above 120 or below 69, utilisation of the formulae might result in a serious under- or over-estimation respectively" (Barona *et al.* (1984), p887). A considerably larger percentage of predicted IQ variance than that obtained by Barona *et al.* (1984) was found by Eppinger *et al.* (1987) in a cross-validation study. They found that the 'Barona formulae' predicted 58%, 61% and 36% of the variance in WAIS-R Full Scale, Verbal and Performance IQ in a "neurologically normal" sample, although the formulae consistently overestimated IQ scores. In discriminating between neurologically normal and brain-impaired groups, however, Eppinger *et al.* (1987) concluded that, although the discrepancy scores between predicted and obtained IQ achieved slightly higher rates of correct patient classification, they needed to provide greater diagnostic accuracy to be used in clinical settings.

The appeal of the demographic approach has centred around its major advantage in that it provides an estimate of premorbid IQ that is totally independent of a patient's current cognitive functioning. No possibility exists, therefore, for the estimate to be subject to decline, unlike tests of current psychometric functioning (Crawford, 1992). A disadvantage of the approach, however, rests on the fact that demographic equations can only explain approximately 50% of the variance in measured intelligence, leaving a remaining 50% unaccounted for (O'Carroll, 1995). Further, O'Carroll (1995) puts forward the view that the disease process in neurodevelopmental conditions such as schizophrenia may begin sufficiently early to compromise an individual's educational and occupational accomplishments. This could then lead to an underestimate of the individual's actual premorbid abilities. It is therefore crucial that individual circumstances are taken into consideration when employing demographically based equations as a measure of premorbid abilities.

1.2.3 Tests of Reading Ability

In attempting to improve on vocabulary and demographically based methods of estimating the cognitive deterioration of patients with neurological disorder, Nelson & McKenna (1975) were the first to suggest that reading ability may be used to estimate premorbid levels of functioning in patients suffering from dementia. This was based on the observation that reading ability, namely accuracy of oral pronunciation, was relatively well preserved in dementing individuals until late on in the disease process. It was hypothesised that reading could be used as an indicator of premorbid intelligence if reading ability correlated with IQ in the normal population and did not deteriorate in cases of dementia. Nelson & McKenna tested this hypothesis by administering the already established Schonell Graded Word Reading Test (Schonell, 1942) and the WAIS to a sample of demented patients and controls. They did indeed find that word-reading ability and general intelligence were highly correlated in the normal control group. Deriving a regression equation from the normative data enabled them to calculate reading IQ equivalence scores for the group of dementing patients. It was found that the IQ levels predicted from the Schonell were significantly higher than those measured using the WAIS. Comparing the groups, mean scores on the WAIS were significantly higher in the control group as expected, however there was no significant difference in the performance between controls and the demented group on the Schonell. This demonstrated that the Schonell was considerably more resistant than the WAIS to generalised cerebral dysfunction. Nelson & McKenna also found that reading provided a better measure of premorbid ability levels than even the Vocabulary subtest of the WAIS, which allowed them to conclude that oral reading of single words could be used as a reasonable predictor of premorbid IQ. Similar results were found in a cross-validation study by Ruddle & Bradshaw (1982).

While the above evidence suggests that the Schonell has substantial potential in predicting premorbid ability levels, it was not without its limitations. The most apparent was that it only allowed the prediction of a maximum IQ of 115, being originally developed to assess reading ability in children. It could not therefore be used to detect subtle degrees of deterioration in subjects who had a high premorbid IQ. A second limitation concerned that fact that the Schonell was predominantly comprised of words with regular grapheme-phoneme correspondences. It was suggested that the use of normal phonological rules would allow most adults to read aloud words that may not be in their reading vocabulary. This was not thought to be the case in people suffering from dementia. As they are no longer able to use phonological rules because of the nature of the disease process, it was hypothesised that dementia sufferers would be substantially worse at reading regular words. This was confirmed by Nelson & O'Connell (1978) who found a significant difference in the performance of controls and patients with cortical atrophy required to read long, unfamiliar regular words.

National Adult Reading Test

In an attempt to overcome the limitations of the Schonell, Nelson (1977) developed what was initially termed the New Adult Reading Test, later re-named as the National Adult Reading Test (NART; Nelson, 1982). This was "a new graded word reading test with words of more appropriate difficulty levels for an adult population" (Nelson & O'Connell, 1978, p235). The NART is a single word, oral reading test of 50 items. It contains only low frequency irregular words which are written in such a way that the application of the normal rules of phonetic interpretation would result in errors of pronunciation (for example, drachm, gaoled). It was suggested that there are two main routes to reading:

- The semantic route, where the corresponding phonological form is accessed when printed words are matched with their lexical entry; and
- The phonological route where the individual graphemes of the word are identified and pronounced according to grapheme-phoneme conversion rules

It was hypothesised that the words used in the NART would be unsuitable for the phonological route because of their irregular pronunciation. In order to read the words aloud correctly, subjects must use the semantic route which maximises the importance of having prior knowledge of the word. If subjects do make errors, it is because they apply grapheme-phoneme conversion rules when attempting to pronounce it as the printed word is unfamiliar, that is, it does not have a lexical entry (Nelson & O'Connell, 1978). In addition, as the majority of the words are short in length, subjects do not have to analyse a complex visual stimulus in order to produce the correct oral response, thereby making minimal demands on current cognitive capacity. Thus, while the reading of 'regular' words may largely depend on the subject's current ability to apply phonetic rules, the use of 'irregular' words was felt to capitalise on the subject's premorbid familiarity with the words and therefore be a more reliable indicator of premorbid ability.

Nelson & O'Connell (1978) standardised the NART on a group of 120 British subjects free of neurological dysfunction. The NART and a short-form WAIS were administered and regression formulae were devised to predict WAIS IQ from the number of NART errors a subject made. In a validation study, Nelson & O'Connell compared the performance of the standardisation sample with a group of 40 subjects with evidence of bilateral cortical atrophy. The results indicated that NART performance was highly correlated with intelligence in the normal population and was found to be superior to the Schonell in so far as it gave a prediction of higher IQ. Further, while the control group obtained significantly higher scores on all WAIS IQ measures than the atrophy group, there was no significant difference in NART performance between the groups. Although the lack of demographic information on the groups warrant that they be interpreted with caution, the results did suggest that reading ability was a relatively well maintained skill in patients suffering from cortical atrophy.

Support for the rationale of Nelson & O'Connell (1978) in choosing irregular words in the NART to force the use of the lexical as opposed to phonemic route to reading was provided by Friedman, Ferguson, Robinson & Sunderland (1992). They investigated the reading of 'pseudowords' - which are letter strings that correspond to grapheme-phoneme correspondence rules and are pronounceable but are not real words - in demented patients and controls. They found that patients were only mildly impaired at reading pseudowords with 'neighbours' (e.g. *fost* {post, host}) but were very impaired reading pseudowords with no 'neighbours' (e.g. *kurj, tivz*). This result arose because words and pseudowords are read using a lexical mechanism. This route is unavailable when there are no analogous neighbours, so normal subjects revert to using grapheme-phoneme pronunciation rules. It was suggested that the patient group were more impaired on the pseudowords with no neighbours because this route was only available to cognitively intact readers.

Following its publication, the NART has become the most popular and widely used measure of predicting premorbid intelligence in a wide variety of clinical conditions and in both clinical practice and research. It is not difficult to see why. The attraction of the test lies in its quick and easy administration and scoring. The NART has also been re-standardised against the revised WAIS (WAIS-R) in Britain (Nelson & Willison, 1991) and has been modified for use in North American populations (Blair & Spreen, 1989). It is essential, however, to consider whether it meets the three basic principles necessary for it to be a valid current ability measure of premorbid intelligence. As indicated above (section 1.3.) the NART must correlate highly with intelligence in the normal population; have adequate reliability and, most crucially, must be insensitive to cerebral dysfunction.

PRINCIPLE 1: CORRELATION WITH INTELLIGENCE

In the original standardisation sample, Nelson (1982) reported that the NART predicted 55%, 60% and 32% of the variance in WAIS Full-Scale, Verbal and Performance IQ based on the short-form of the WAIS. Crawford *et al.* (1989b), examining the predictive ability of the NART regression equations in a cross-validation study of healthy adults, reported that the NART predicted 66%, 72% and 33% of the variance in WAIS Full-Scale, Verbal and Performance IQ when the full length WAIS was employed. The cross-validation and standardisation samples have since been combined in an attempt to generate new formulae which were expected to be more stable than the previous ones (Crawford, 1989). From these results, it can be seen that the NART predicts more of the variance in IQ than demographic methods and as such is a much greater predictor of premorbid abilities.

Factor analytic studies have provided further evidence that the NART is a valid measure of intelligence in the general population. Principal component analysis of the WAIS typically extracts a factor interpreted as general intelligence (*g*) which accounts for a large percentage of the variance. A three factor structure emerges after rotational analysis which have been labelled 'verbal intelligence', 'perceptual organisation' and 'attention/concentration/

freedom from distractibility' (Matarazzo, 1972). A factor analytic study of the NART was carried out by Crawford, Stewart, Cochrane, Parker & Besson (1989d). Results indicated that the NART has high construct validity as a measure of general intelligence, loading very highly on *'g'*, (0.85). Rotational analysis produced a three factor structure consistent with that of the WAIS. While the NART loaded highly on 'verbal intelligence' as expected, it did not load on the 'perceptual organisation' factor. It is also interesting to note that the NART was not shown to have a high loading on the 'attention/concentration/freedom from distractibility' factor, supporting the rationale underlying its use as a measure which taps previous knowledge without placing high demands on current cognitive capacity.

PRINCIPLE 2: RELIABILITY

The NART has been shown to have high reliability. In the original standardisation sample, Nelson (1982) reported that the NART had a split-half reliability of 0.93, which suggested that it has high internal reliability. Crawford, Stewart, Garthwaite, Parker & Besson (1988b) confirmed this finding, reporting a split-half reliability of 0.90. Inter-rater reliability has also been shown to be impressive. As the NART manual suggests that "slight variations in pronunciation are acceptable when these are due to regional accents" (Nelson, 1992, p5), O'Carroll (1987) carried out a pilot study to examine the inter-rater reliability of the NART. Twelve patients were independently scored by ten clinical psychologists of varying experience who used the NART routinely in their clinical practice. A high degree of inter-rater reliability was evident with correlations ranging between 0.89 and 0.99. Crawford, Parker, Stewart, Besson & De Lacey (1989b) replicated and extended O'Carroll's (1987) finding of high inter-rater reliability in a larger sample with a wider range of NART performance. Correlations ranged between 0.96 and 0.98. Crawford *et al.* (1989b) also concluded that previous experience with the NART was not necessary to score it reliably, although they did indicate that care should be taken with 5 words in particular that had the lowest agreement rates. Finally, the NART appeared to have acceptable test-retest reliability. Crawford *et al.* (1989b) reported a reliability coefficient of 0.98 in a sample of 61 subjects free of neurological disorder. A slight practice effect was observed but this was considered to be "of little practical significance" (p.270).

PRINCIPLE 3: RESISTANCE TO CEREBRAL DYSFUNCTION

The third principle on which the NART is based is that it remains genuinely unaffected by conditions that impair other cognitive functions. Clinically, a marked discrepancy in favour of NART estimated IQ over currently measured IQ suggests decline from a previously higher level of ability. Thus the true premorbid abilities of a subject will be underestimated if their performance on the NART has suffered impairment. There is some concern, however, about the way the NART has been used in a 'band-wagon' manner, predicting premorbid abilities in a variety of clinical conditions where this assumption has never been examined (O'Carroll, 1995). A variety of methods of evaluating the resistance of NART performance to dysfunction have been conducted. These include;- comparisons between clinical groups and healthy subjects matched on demographic variables, longitudinal investigations of those suffering from progressive conditions, and correlations between NART performance and 'impairment sensitive' measures.

Dementia

Nelson & O'Connell (1978) were the first to suggest that the NART was resistant to the effects of dementia when they reported that patients with cortical atrophy did not perform significantly differently from controls on this measure. Several studies since then have confirmed that there is no apparent detrimental effect on NART performance in Alzheimer's disease and multi-infarct dementia. Crawford *et al.* (1988) found no significant difference in NART performance between groups of matched healthy controls and patients with either Alzheimer's disease or multi-infarct dementia. This was despite the fact that the Alzheimer's group showed evidence of marked cognitive impairment confirmed by findings of gross cortical atrophy on NMR brain imaging. Nebes, Martin & Horn (1984) have also reported that the NART performance of patients with Alzheimer's disease was not significantly different from matched controls. In a longitudinal study, O'Carroll, Baikie & Whittick (1987) assessed patients with Alzheimer's disease and multi-infarct dementia on the NART and other cognitive measures, on two occasions, one year apart. No decline in NART performance was reported at the second assessment, unlike the decline observed on a vocabulary test and the significant increases in measures of dementia severity. Further evidence that gave credence to the view that the NART is resistant to dementia has been provided by O'Carroll and Gilleard (1986), who demonstrated that there was no significant correlation between various measures of dementia severity and performance on the NART. To test whether the NART improved discrimination between impaired and non-impaired subjects by providing an individualised comparison standard, Crawford, Hart & Nelson (1990) carried out a series of discriminant function analyses in a sample consisting of healthy subjects and patients with dementia. Inclusion of the NART was found to significantly improve discrimination between impaired and non-impaired individuals.

In contrast, more recent articles have suggested that reading may not be preserved in patients with dementing disorders of moderate severity. Fromm, Holland, Nebes & Oakley (1991) found that Alzheimer's patients performance on the NART was significantly worse over time when they were assessed over three years at yearly intervals. NART performance was only sensitive to dementia severity at the last assessment in the latter stages of the disease. Hart *et al.* (1986) have also found that NART did not 'hold' in dementia. The NART was administered to patients with Alzheimer's disease and matched controls. The NART performance of the Alzheimer's patients was significantly lower than that of the controls, however, it yielded estimates that were significantly higher than those derived from performance on either the Schonell or the WAIS vocabulary subtest. This led them to suggest that the NART based estimates, in terms of the discrepancy between predicted and obtained IQ, were a better indicator of premorbid functioning and were "more stable in the face of progressive intellectual decline" (p.123). This result was mirrored in a longitudinal study by Paque & Warrington (1996), who found that although performance on the NART did decline gradually over time in subjects with dementia, deterioration on formal tests of IQ was more rapid and severe. They also concluded that, on the whole, the NART can be used to predict the premorbid functioning of patients with dementia. Stebbins *et al.* (1990) produced results that the NART is not entirely resistant to the effects of dementia when they demonstrated that the NART was impaired in moderately and severely demented patients, but not in those with mild dementia. Further, Hodges, Patterson, Oxbury & Funnell (1992) presented five cases of 'semantic dementia', a term used to describe patients with a breakdown in semantic knowledge. A pattern of surface dyslexia (superiority of regular and non-words over irregular words) was evident in these cases as was disordered language and memory functions. Patients with surface dyslexia had difficulty reading NART words which led to low estimates of premorbid IQ. Patterson, Graham & Hodges (1994) provided further evidence which raised serious doubts about the use of the NART in Alzheimer's disease. A group of 45 patients, in which dementia severity ranged from minimal to moderate as assessed by the Mini Mental State Examination (Folstein, Folstein & McHugh, 1975), were assessed on a variety of measures of semantic memory and reading. Semantic memory declined as disease severity increased and the authors found a parallel decline in NART performance with increasing disease severity. At a stage of only moderate dementia, the NART underestimated premorbid intelligence by approximately 15 IQ points. This was explained by the fact that reading the irregular words of the NART relied on intact semantic representations of such words which was shown to breakdown in Alzheimer's disease.

The available evidence to date suggests, therefore, that the NART should only be used to estimate premorbid intelligence in patients with mild dementia (O'Carroll, 1995), however this usually appears to be where the major diagnostic problems occur. Indeed, the use of the NART would be largely unnecessary where there is cerebral dysfunction severe enough to impair performance on such a test, as intellectual deterioration may be already blatantly obvious.

Closed Head Injury

In contrast to the wealth of literature on the use of the NART in estimating the premorbid abilities of patients with dementia, there has been very little research into its use in closed head injury, despite its widespread use when conducting neuropsychological assessments for clinical or medico-legal purposes (McKinlay & Gray, 1992). Crawford *et al.* (1988), in a large study which looked at NART performance in a number of organic conditions, compared the performance of 18 subjects with closed head injury who showed evidence of impairment in intellectual and social functioning with individually matched controls. No significant difference in NART performance was found between the closed head-injury group and matched controls. Further, it was interesting to note that the closed head-injury group did not perform significantly more poorly than the controls on the Vocabulary subtest of the WAIS either. This indicated that both measures of premorbid ability were found to 'hold' in this group of head-injured subjects. The above study by Crawford *et al.* (1988) only inferred that this clinical group, had they not had a head-injury, would have had the same premorbid IQ as the control group because no actual premorbid data were available. A study which provided the most convincing evidence to date of the utility of the NART in closed head injury was provided by Moss & Dowd (1991). A single case study was reported of a man who sustained a severe closed head injury in a road traffic accident, on whom an intelligence test had been administered prior to the accident. Neuropsychological evaluation was carried out for medico-legal purposes and included the use of NART to estimate premorbid IQ. There was no evidence of language difficulties. The NART was found to produce a very accurate estimate of premorbid IQ in this case, supporting its validity in predicting premorbid intellectual ability in patients who have sustained a closed head-injury. It would appear, however, that further research into the utility of the NART in closed head-injury is long overdue.

Korsakoff's Syndrome

Many researchers have used the NART to estimate premorbid intellectual abilities in patients with alcoholic Korsakoff's syndrome (Kopelman, 1991: Leng & Parkin, 1988). Crawford *et al.* (1988), however, compared a sample of 12 alcoholic Korsakoff patients with individually matched control subjects and reported that the Korsakoff's patients performed significantly more poorly on the NART. The validity of estimating premorbid ability in alcoholic Korsakoff's patients using the NART was also examined by O'Carroll, Moffoot, Ebmeier & Goodwin (1992a) using four different techniques. 20 Korsakoff's patients were compared with 40 healthy controls using a group comparison approach. Firstly, highly significant differences were found between the two groups in their performance on the NART, with patients making more errors than controls. Secondly, demographically predicted intellectual level was found to be significantly higher than that predicted by the NART. Thirdly, Korsakoff's patients made significantly more NART errors than were predicted by demographic variables, whereas control subjects made significantly less. Finally, NART performance in Korsakoff's patients was found to be significantly correlated with the severity of memory dysfunction. O'Carroll *et al* (1992a) suggest that the explanation for this failure to correctly pronounce irregular words may be due to the confabulatory tendencies exhibited in this syndrome, proposing that Korsakoff's patients do not "cognitively error-check" their responses. It is clear, however, that the NART should not be used to estimate premorbid intellectual functioning in this clinical condition, yet despite these findings, it is (e.g. Joyce & Robbins, 1991; Shoqeirat & Mayes, 1991).

Depression

Crawford, Besson, Parker, Sutherland & Keen (1987) have reported that there was no significant difference in NART performance between a sample of depressed patients and healthy matched controls despite impairment on WAIS vocabulary. Austin, Ross, Murray, O'Carroll, Ebmeier & Goodwin (1992) found similar results whereby depressed patients did not differ significantly from controls on NART performance despite the depressed group performing significantly more poorly on measures of recall, recognition and psychomotor speed. These results are taken as evidence, therefore, that NART performance is unimpaired in major depression.

Huntington's disease

Crawford *et al.* (1988) have also shown that NART performance is impaired in patients suffering from Huntington's disease. Six Huntington's patients performed significantly more poorly on the NART than individually matched controls, although the NART did produce a significantly higher estimate than the vocabulary subtest of the WAIS. This result has subsequently been confirmed in a larger study of patients with Huntington's disease (Blackmore, Crawford & Simson (1994).

Schizophrenia

In an attempt to investigate cognitive decline in neurodevelopmental conditions, the NART has been used in a number of research reports to estimate premorbid intellectual functioning in patients with schizophrenia (O'Carroll, 1995). Crawford, Besson, Bremner, Ebmeier, Cochrane & Kirkwood (1992) investigated two groups of schizophrenics, one long-stay residents, the other community residents. NART performance was not significantly different between community resident schizophrenics and individually matched controls, however, performance was significantly lower in the long-stay schizophrenics. It was concluded that the low NART performance could be a valid indication of low premorbid functioning in the long-stay sample, however it cannot be ruled out that NART performance was compromised by the disease process, therefore it has been recommended that the NART is not used in this condition. In contrast, O'Carroll, Walker, Dunan, Murray, Blackwood, Ebmeier & Goodwin (1992b) investigated the use of the NART in acutely ill, unmedicated schizophrenic patients who were compared with healthy controls. No group differences were noted in NART performance so the authors concluded that the NART may provide a reasonable estimate of premorbid levels of functioning in acutely ill, unmedicated schizophrenics.

Brain Tumours

In a pilot study, Ebmeier, Booker, Cull, Gregor, Goodwin & O'Carroll (1993) have shown that the NART must be used with great care in survivors of malignant brain tumours. They compared the performance of the NART in a group of 16 long-term survivors of glioma who had gone through whole brain irradiation with a group of matched controls and found that the patients, even after controlling for demographic differences between the groups, made significantly more NART errors than the control group.

To summarise, some encouraging results have been published which suggest that the NART is relatively resistant to the effects of cerebral dysfunction, especially when studies have compared its performance with that of the vocabulary subtest of the WAIS. However, the NART must not be used indiscriminately in clinical conditions where its validity has never been questioned given that its performance has been shown to be significantly impaired in conditions such as moderate to severe dementia, Korsakoff's syndrome, Huntington's disease, long-term schizophrenia and glioma.

SHORT-FORM NART

Due to their observation that asking elderly people to read irregular and difficult words may cause distress, Beardsall & Brayne (1990) developed a short-form of the NART (termed the Short NART) for subjects who failed more than five of the first twenty-five items, and particularly those who failed many and were therefore confronted with repeated failures. For those who pronounced between twelve and twenty of the words correctly, a procedure enables the clinician to estimate a full NART score; scores lower than this were assumed to be no different than the total score would have been if the full list had been administered. In a cross-validation study, Crawford, Parker, Allan, Jack & Morrison (1991) reported that while estimates of IQ obtained by this method correlated well with NART estimates with "virtually equivalent" accuracy, application of the Short NART still left a considerable unexplained variance and produced a small percentage of subjects whereby there were sizeable discrepant estimates between predicted and obtained NART scores. The authors also suggested that the Short NART complicated the scoring of a test whose strength lies in its ability to be easily scored. In addition, as Crawford *et al.* (1991) noted, the fear that the full length NART induced anxiety was not in keeping with the experience of many neuropsychologists. Subjects are usually unaware if they have made pronunciation errors and the NART has been specifically designed to access previously established knowledge without placing great demands on cognitive effort. It seemed unlikely, therefore, that subjects would be able to manage more complicated tests of current intellectual functioning if they were unable to complete the NART (Crawford *et al.* 1991).

VERBAL FLUENCY AND THE NART

The relationship between brain damage and intellectual test performance among individuals is highly variable and depends on factors such as type, extent, location and acuteness of the damage (Lezak, 1995). The acute disruption of brain functioning frequently results in sudden impairments in intellectual capacities which generally improves over a period of years (Mandelberg & Brooks, 1975), but typically reaches a plateau within the first 6 months to a year after injury (Lezak, 1995). Recovery on neuropsychological tests is typical, however intellectual impairment can persist in patients whose test results are back to normal (Klonoff, Low & Clark, 1977). Lezak (1995) noted that many patients can perform adequately on conventional neuropsychological test batteries and has stated that traumatically brain-injured adults have achieved score patterns on the WAIS that approximate the average. Verbal Fluency tests, on the other hand, are widely used in the assessment of current cognitive impairment and are a good indicator of subtle residual impairments especially if there has been involvement of the frontal lobes (Lezak, 1995). With this in mind, Crawford, Moore & Cameron (1992) carried out the first study using the NART to predict premorbid ability for a test other than the WAIS. They administered the NART and Controlled Oral Word Association Test (Benton & Hamsher, 1989) to a sample of 142 healthy subjects and regression formulae were devised to predict Verbal Fluency from the number of NART errors a subject made. The belief was that it would be preferable to use the NART to obtain an individualised comparison standard for current performance on Verbal Fluency, rather than simply using normative data, following the observation that control subjects of low ability can perform less well than brighter brain-damaged patients. The authors reported a highly significant correlation between the NART and Verbal Fluency in the healthy standardisation sample ($r= .67$), indicating that premorbid ability should be considered when interpreting Verbal Fluency scores. In the validation study, Crawford *et al.* (1992) compared predicted and obtained Verbal Fluency scores in a sample of neurological patients and found a highly significant difference in favour of NART predicted Verbal Fluency performance over obtained Verbal Fluency performance. This provided support for the utility of the NART in detecting impairment in a neurological sample (Crawford *et al.* 1992).

LIMITATIONS OF THE NART

Although the NART is a valuable test of premorbid intellectual functioning, it does have its limitations, not least in the indication that its validity in certain conditions is questionable (for example, in moderate to severe dementia, Korsakoff's syndrome). Indeed, although it cannot be assumed that performance on any current ability test is entirely unaffected by severe neurological disorders, some studies mentioned above have reported findings of deterioration in NART performance. To investigate this in the individual case, Crawford, Allan, Cochrane & Parker (1990) developed a regression equation to predict a subjects actual NART score from demographic variables. Comparing the predicted NART error score with the obtained NART score would allow clinicians to objectively determine whether there is impaired NART performance. Further limitations of the NART have been highlighted by Baddeley *et al.* (1993) who argue that its use is unsuitable with patients who have dyslexia or who have visual acuity or articulatory problems. It may also underestimate the intelligence of self-educated individuals who may have obtained their knowledge of vocabulary through reading, with the result that they are not skilled in the pronunciation of a word although are familiar with its meaning.

Combining the NART and Demographic Variables

Although the above evidence suggests that the NART predicts more of the variance in IQ test performance than demographic variables, Crawford *et al.* (1988b) suggested that combining the approaches would increase the amount of predicted variance in premorbid IQ. Crawford, Stewart, Parker, Besson & Cochrane (1989e) therefore developed multiple regression equations combining the NART and demographic variables. It was hypothesised that these would have a "cumulative effect" on predicted IQ variance, given that [1] there may be unshared variance between the NART and demographic variables; and [2] demographic variables and NART performance are correlated with measured intelligence (Crawford *et al.* 1989e). The combination of NART and demographics increased the amount of explained variance, predicting 73%, 78% and 39% in Full-Scale, Verbal and Performance IQ respectively, an increase of around 7% over the NART alone. This finding has been confirmed in a subsequent cross-validation study by Crawford, Nelson, Blackmore & Cochrane (1990f). The construct validity of the combined NART/demographic equation has also been investigated by Crawford, Cochrane, Besson, Parker & Stewart (1990c) who found that the loading for this estimate on general intelligence *(g)* (0.9) was higher than any of the WAIS subtests.

While an Australian study has also reported that better estimates of premorbid intellectual functioning are observed when the NART and demographic variables are combined (Willshire, Kinsella & Prior, 1991) studies in North America have failed to replicate this finding. Blair & Spreen (1989) in Canada and Grober & Sliwinski (1991) in the United States both reported that the inclusion of demographic variables did not improve the prediction of intellectual functioning. The combination of NART and demographics appears, therefore, to be the method of choice in estimating premorbid functioning in the UK and Australia, but not in North America where there may be cultural differences mediating the relationship between demographic variables, the NART and IQ.

Modification of the NART - The Effect of Contextual Cues

The assumption that subjects who do not pronounce NART words correctly have no prior knowledge of the word has been questioned by Beardsall & Brayne (1990). The results of their standardisation study on the short NART revealed that a number of less-well educated elderly people often mispronounced even some of the more common NART words, for example, mispronouncing psalm as palm and depot to rhyme with teapot. This tendency was even more obvious in subjects with dementia. The authors believed that such words were likely to be in their subjects' vocabulary and were used and read in everyday life. It was therefore hypothesised that mispronunciation may not necessarily indicate that the subject has no previous familiarity with the word but may be the result of subjects failing to recognise words because of a lack of contextual information which would normally access the lexical entry (Beardsall & Huppert 1994). It has also been suggested that subjects must use the 'semantic route' when reading irregular words as the 'phonological route' is unavailable, thereby assuming that subjects have no previous familiarity of a word - or lexical entry - if they are unable to pronounce it correctly. Beardsall & Huppert (1994) have proposed, however, that there is a third route to reading - the 'lexical-phonological' route, based on the observation that errors made in the pronunciation of irregular words do not necessarily follow the application of typical grapheme-phoneme conversion rules. Some errors are based on a lexical entry that is visually similar to the unfamiliar word (for example, pronouncing psalm as palm). Thus errors may occur despite there being a lexical entry because subjects are not necessarily using the semantic route when reading irregular words. The fact that errors may not in fact be due to a subjects unfamiliarity with the word led them to suppose that the NART would provide an underestimate of premorbid IQ, as the method of presentation does not allow access to a lexical entry.

To try to access whether there is a lexical entry and thus whether subjects do in fact have knowledge of the meaning and correct pronunciation of NART words, Beardsall & Huppert (1994) modified the original NART presentation by placing the irregular words into sentences to provide a semantic and syntactic context as in everyday life. The advantages of this development - the Cambridge Contextual Reading Test (CCRT) - were that it was seen to be more acceptable to elderly subjects than reading a list of complicated words and would reduce the possibility of guesswork on the basis of certain phonetic aspects of the word. The Short CCRT and the Short NART were administered to patients with dementia and healthy controls. Both normal and demented subjects significantly improved their performance when words were seen in context. Further, it was evident that this improvement was most apparent for demented subjects and for poor or average readers, while skilled readers demonstrated little benefit with the inclusion of contextual information. Beardsall & Huppert (1994) concluded that words were in a subject's lexicon, and therefore familiar, if they correctly pronounced CCRT words that were mispronounced and therefore not accessed by the NART. By providing a context the CCRT facilitated subjects recognising words as familiar "thereby accessing the lexicon and the phonological representation of the stored word" (p239-40). Law (1996) has also found that normal and demented subjects significantly improved their pronunciation performance when NART words were seen in context. These findings indicate that the CCRT does provide a more accurate estimate of premorbid functioning than the NART as the effect of context increases the probability of recognising the irregular NART word. It should therefore be seen as a useful modification to the NART, especially for poor and average readers and for subjects with dementia.

Beardsall & Huppert (1997) have since provided evidence that the CCRT is a valid measure of intelligence with the finding that it correlated with WAIS-R Verbal IQ. Regression equations built to examine the predictive ability of the CCRT revealed that it predicted 61% of the variance in WAIS Verbal IQ and 68% when combined with demographic variables.

Further research would be particularly useful to determine whether the CCRT would provide a more accurate estimate of premorbid intellectual functioning than the NART in other clinical conditions such as head injury.

1.2.4 Tests of Lexical Decision Making

In an attempt to address the limitations inherent in the NART, an alternative method of estimating premorbid intellectual functioning has been proposed by Baddeley *et al.* (1993), who developed a test based on lexical decision making - the 'Spot-the-Word' test. As previously indicated, the NART and consequently its successor the CCRT, have been criticised because they involve reading words aloud, preventing their use with patients who have dyslexia or those who have visual acuity or articulation problems. The NART and CCRT may also underestimate the intelligence of those self-educated individuals who have obtained their vocabulary knowledge through private reading, with the result that they may be familiar with the word but do not know how to pronounce it. The Spot-the-Word is a simple recognition test whereby a subject is asked to identify which of a pair of letter groups is a real word and which is the invented meaningless word. It consists of 60 pairs of items and has two parallel forms to overcome the difficulties of practice effects from repeat assessment. The non-words were devised to look like a word in that they were similar in length to real words and were easily pronounced by following rules of orthography. This task was seen to offer a number of advantages over the NART (Baddeley *et al.* 1993). As the Spot-the-Word test is based on lexical decision making, it was proposed that the task could be successfully performed via a number of different routes based on various features of the word, such as its meaning, how it sounds, its appearance or its overall general familiarity. It was argued that, because lexical decision making can be based on any of these different features - unlike the NART which relies on one single characteristic for successful performance (namely, correct pronunciation) - the Spot-the-Word would be much less likely to be affected by brain damage (Baddeley *et al*, 1995). Other benefits were seen to include its ability to be presented not just in a visual form, but auditorily, thereby providing a measure that could be used in groups where the NART is inappropriate. The test can also be given to a number of subjects at a time as it does not involve an oral response. Further, given that the words in the test are not dependent on orthographic irregularity, the Spot-the-Word can be translated into other languages. This overcomes the difficulty inherent in the NART where it is unable to be modified for use in countries where there is an absence of irregular words (e.g. Italian).

Baddeley *et al.* (1995) investigated the reliability and validity of the Spot-the-Word test in two samples of healthy subjects. It was reported that performance on the Spot-the-Word correlated highly with other measures of verbal intelligence - 0.69 with the Mill Hill Vocabulary Test and 0.87 with the NART - suggesting that it was a valid measure of verbal intelligence. In addition, a high degree of parallel form reliability was demonstrated (0.883). Baddeley *et al.* also attempted to assess whether the Spot-the-Word was resistant to the effects of cognitive decline in the elderly. They found that there was no evidence of decline in performance on the Spot-the-Word with age, elderly subjects scoring well regardless of whether they were suspected of having intellectual deterioration or not.

Beardsall & Huppert (1997) investigated whether the Spot-the-Word was resistant to organic impairment and provided the first indication to suggest it was susceptible to the effects of dementia. They compared groups of healthy elderly controls and subjects with dementia on their performance on the NART, CCRT and Spot-the-Word and found that those subjects with mild to moderate dementia performed significantly more poorly on the Spot-the-Word. In addition, they noted that the Spot-the-Word consisted of single words with no contextual information, thereby falling into the problem which was originally encountered in the NART.

Clearly, this approach to estimating verbal intelligence needs to be investigated further to determine whether it remains genuinely resistant in other conditions where cerebral dysfunction is apparent.

1.3 AIMS AND HYPOTHESES

As a result of the foregoing discussion, it is evident that further research into the assessment of premorbid intellectual functioning in closed head injury is overdue. Reliable and meaningful methods for determining premorbid intellectual levels of patients with closed head-injury are essential to aid in the evaluation of intellectual deterioration, in establishing treatment and rehabilitation goals and in resolving medico-legal issues. However, in contrast to the wealth of literature on the use of the National Adult Reading Test in estimating the premorbid abilities of patients with dementia, there has been very little research into its use in closed head injury. Further, the use of recently developed alternative measures of estimating premorbid intellectual functioning in dementia, such as the Cambridge Contextual Reading Test and Spot-the Word test, need to be examined in other clinical conditions such as closed head-injury. This is the purpose of the current study.

In carrying out research into head-injury, Antonak, Livneh & Antonak (1993) have recommended that a suitable comparison group should be included, the absence of which limits any conclusions that can be drawn from the research. Any differences observed cannot unequivocally be attributed to head injury as a neurologic impairment unless there is evidence that the differences are <u>not</u> accounted for by other variables of the individuals studied. For this reason, an orthopaedic trauma group is included to determine whether any differences found are the result of either the effects of the brain injury itself or the effects of other variables such as the psychological effects of the trauma. It is hypothesised that the orthopaedic control group will not be significantly different from a healthy, non-traumatised control group and thus any differences observed in the head-injured group will be attributable to the effects of the brain injury (and not, then, to the psychological effects of trauma).

The aim of the present study is, therefore, to compare the performance of head injured subjects with two control groups, a non head-injured orthopaedic trauma control group and a healthy, normal, non-traumatised control group, on three measures of premorbid ability - the NART, CCRT and Spot the Word test.

It is hypothesised that:

[1] There will be no significant differences between the head-injured group and the control groups on the measures of premorbid intellectual functioning (NART, CCRT, Spot-the-Word) irrespective of their severity of head-injury, however, it is expected that the head-injured subjects will perform significantly more poorly on measures of current intellectual functioning (WAIS-R, MMSE, Verbal Fluency, Stroop).

Further, if performance on the measures of premorbid abilities is unaffected by head-injury, then such measures will not be related to measures of head-injury severity.

[2] The NART, CCRT and Spot the Word tests will correlate with measures of current intellectual functioning in the healthy control group and thus provide a valid estimate of premorbid intellectual functioning. The CCRT and Spot-the Word will also correlate highly with the NART if they are valid premorbid measures.

[3] Head injured and control subjects will show better pronunciation performance on the CCRT (when words are seen in context) in comparison to their performance on the NART, demonstrating that reading ability is improved by context. This will provide a more valid estimate of premorbid intelligence.

Further, subjects with a head injury or with poor or average reading ability will benefit more from the inclusion of contextual cues than those with good reading ability.

[4] Addition of demographic variables to the NART, CCRT and Spot the Word will improve the amount of explained variance in predicted Full-Scale IQ, Verbal IQ and Performance IQ.

2. METHOD

2.1 DESIGN

The current study is cross-sectional in nature and was conducted to examine the validity of premorbid measures of intellectual functioning in closed head injury. The study employed both between-subject and within-subject comparisons and correlational designs.

The study was approved by the Sub-Committee for Psychiatry and Psychology of the Lothian Health Board Research Ethics Committee.

2.2 SUBJECTS

2.2.1 Selection Criteria

In order to reduce the effects of certain confounding variables, any subject with a significant history of substance dependence or a psychotic condition was excluded from the study. In addition, subjects were not included if they had a history of dyslexia or visual or articulatory problems. All control subjects had to be between 18 and 65 years of age and were screened to exclude the possibility of acquired cognitive impairment using the Mini-Mental State Examination (Folstein *et al.*, 1975). Head-injured subjects had to be between 18 and 55 years of age. The younger age limit for the head-injured group was set following the observation by Gaultieri & Cox (1991) of a greater likelihood of head-injured patients developing dementia. Finally, to control for the occurrence of any practice effects, subjects were not included if they has been assessed with the same neuropsychological test materials in the 6 months prior to their participation in the study. In all cases, informed consent to take part in the study was obtained from subjects themselves.

2.2.2 Head Injured Group

To identify suitable patients for inclusion in the study, a search was made through the casenotes of patients who were discharged from the Scottish

Brain Injury Rehabilitation Service at the Astley Ainslie Hospital over a two year period. The criteria for selection specific to the head-injured group were:

- subjects must have had a closed head injury at least 9 months prior to the start of the study (to ensure that they were medically stable);
- subjects must be between 18 and 55 years of age (to try to exclude those who may have developed dementia (Gaultieri & Cox, 1991)).
- subjects must be living within reasonable travelling distance (50 mile radius).

This search yielded a total of 35 possible subjects who met the inclusion criteria. Individual consultant neurologists were contacted and their consent obtained before subjects were approached. A letter from the consultant was then sent to subjects explaining the purpose of the study and inviting them to return a tear-off slip indicating whether they wished to take part or not. 20 subjects agreed to participate in the study, 6 subjects did not wish to take part, 7 did not reply and 2 had moved elsewhere. If subjects agreed to participate, an appointment was arranged either at their home or at the hospital, whichever was preferable. They were then asked to bring the signed consent form to the assessment session. A further 5 subjects were recruited after being invited to take part in the study when seen as part of a routine follow-up at the Clinical Psychology Department at the Astley Ainslie Hospital.

The final head injured group was composed of 25 patients all of whom had sustained a closed head injury at least 9 months prior to the start of the study.

2.2.3 Orthopaedic Trauma Control Group

This group was composed of patients who had been admitted to the Royal Infirmary of Edinburgh Orthopaedic wards and who met the criteria outlined in section 2.2.1. In addition, subjects in the orthopaedic control group must not have had a history of neurological trauma such as a previous head injury which resulted in unconsciousness. A consultant orthopaedic surgeon approached subjects who met the selection criteria and asked their permission to be contacted to take part in the study. The final orthopaedic control group consisted of 20 patients between 20 and 60 years of age, 16 of whom were in-patients and 4 who were out-patients. Only one subject declined to take part in the study.

2.2.4 Healthy Normal Control Group

This group was composed of 50 healthy subjects between 18 and 65 years of age who were recruited from community groups, non-medical health service personnel and ad-hoc contacts which included acquaintances of the author or previous participants. Again, subjects were included if they met the criteria outlined above and did not have a history of neurological trauma resulting in unconsciousness. All those who were invited to participate agreed to take part and no subject was excluded on the basis of the criteria outlined in section 2.2.1.

2.3 PROCEDURE

To maintain privacy and confidentiality, all interviews were carried out with only the author and subject present. Demographic variables were recorded for each subject which included age, sex, postcode, duration and level of education, current occupation and maximal occupation (highest level of employment attained). Postcodes were recorded in order to obtain a Deprivation Category for each subject (Carstairs & Morris, 1991), which ranged from 1 (Affluent) to 7 (Deprived), whilst social class was derived from a subject's occupation using the Office of Population Censuses and Surveys (1991) Classification of Occupations. Consistent with the recommendations of Crawford *et al.*, (1989), in addition to years full-time education, subjects were credited with 0.25 of a year for every year of attendance at day release or evening classes providing they were leading to a qualification. A review of each head injured subject's medical notes was also undertaken to obtain the cause and severity of head injury. The severity of head-injury sustained was determined by the Glasgow Coma Scale rating as the duration of post-Traumatic Amnesia was very rarely recorded. The amount of time since the injury occurred was also recorded.

Each subject was asked to complete the assessments in a single testing session which lasted approximately 60 minutes. No interview required more than one testing session and the assessments were administered in the same order for all subjects, which was as follows:

- Visual Acuity Test
- National Adult Reading Test,
- Cambridge Contextual Reading Test
- Spot the Word Test
- Wechsler Adult Intelligence Scale-Revised (Short Form)
    - Block Design
    - Comprehension
    - Object Assembly
    - Similarities
- Mini-Mental State Examination
- Controlled Oral Word Association Test
- Stroop
- Hospital Anxiety and Depression Scale

It is important to note that, consistent with the recommendations of Beardsall & Huppert (1994), the presentation of the NART and CCRT was not counterbalanced. It was suggested that if the CCRT was to be presented first, then reading the words in context could facilitate their correct pronunciation when they are subsequently presented in the traditional single-word (NART) format. Beardsall & Huppert (1994) therefore suggested that the NART should be presented first, stating that it would be very difficult to explain how improvement in word reading could be a reflection of a practice effect, i.e. how pronouncing a word incorrectly on one occasion would prime its correct pronunciation on the next occasion.

Copies of all assessments can be found in Appendix 1.

2.4 ASSESSMENT MEASURES

2.4.1 Visual Acuity Test

Subjects were required to read aloud a list of 10 simple single regular words which were printed in lower-case type. This was to ensure that they had adequate visual acuity before proceeding on to the rest of the assessment. No subject was rejected on the basis of this test. All subjects who required glasses wore them during the assessment.

2.4.2 Measures of Premorbid Intellectual Ability

National Adult Reading Test (Nelson, 1982; Nelson & Willison, 1991)

As indicated above, this is a commonly used measure of premorbid functioning which provides estimates based on the oral pronunciation of irregular words. The NART is a single word, oral reading test of 50 items. The majority of words are short and all are phonologically irregular, for example, *drachm, gaoled, demesne.* The NART was administered in the manner described in the test manual (Nelson, 1982) whereby the subject is presented with the list of words and asked to read them aloud. The following instructions were given:

> *'I want you to read slowly down this list of words starting here.' (ACHE indicated). 'After each word, please wait until I say "next" before reading the next word. I must warn you that there are many words that you probably won't recognise, in fact most people don't know them, so just have a guess at these, OK? Go ahead.'*

As the subject read the words, any errors made were recorded. The short version of the NART (Beardsall & Brayne, 1990) was used in one instance where a head-injured subject pronounced only 4 words correctly on the first half of the full NART. Following the recommendations of Beardsall & Brayne (1990), the score obtained was taken as the total score as it was reported that subjects who scored less than 12 were unlikely to improve the score by completing the end of the test (Beardsall & Brayne, 1990).

The total NART error score was then used to obtain a predicted WAIS-R Full-Scale, Verbal and Performance IQ using the equations in the test manual. A conversion table for predicting IQ from each NART error score is provided for ease of use.

Cambridge Contextual Reading Test (Beardsall & Huppert, 1994)

The CCRT is a modification of the original NART presentation which involves placing the irregular words into sentences to provide a semantic and syntactic context as in everyday life, information which is not available in the single word reading list. The sentences were developed to give cues to the word before it was read, for example:

> *'The prisoner was **gaoled** for five years, although he said, "I **deny** all of the charges against me."'*
>
> *'Towards the end of the church service, the **prelate** told the little children the story about the **leviathan**.'*

Subjects were asked to read the sentences at their own pace. The amount of actual errors made was recorded.

Spot the Word Test (Baddeley et al. 1993)

The Spot-the-Word is a test aimed at estimating premorbid intellectual functioning based on lexical decision making. It is a simple recognition test whereby a subject is asked to identify which of a pair of letter groups is a real word and which is the invented meaningless word. The test has two parallel forms and each consists of 60 pairs of items. The non-words were invented so as to be similar in length to the real words and follow English orthography rules. The real words ranged from those which were simple through less common words to obscure words. Examples of non-words included *strubbage, vellicle and psynoptic,* while real words included *livid, tangible and viridian*. Subjects in this study were asked to complete Form A, which consisted of two pages of 30 word pairs. The following instructions were given:

> *'Each of the pairs of items below contains one real word and one nonsense word, invented so as to look like a real word but having no meaning. Please tick the item in each pair that you think is the real word. Some will be common words, most will be uncommon and some very rarely used. If you are unsure, guess, you will probably be right more often than you think.'*

Subjects were then given six practice pairs and asked if there were any questions. If any subject was hesitant over which word to select, they were encouraged to guess rather than missing out the item. A total error score from the two lists was then calculated out of a possible 60.

2.4.3 Measures of Current Intellectual Ability

Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981; Lea, 1986) (Short Form)

This is a widely employed instrument used to measure current intellectual functioning and detect intellectual impairment which has been described as "the workhorse of neuropsychological assessment" (Lezak, 1995). The original WAIS-R contains eleven different subtests to make up the battery. Ideally, when using the WAIS-R, this full-length version should be employed, however, short-forms have been administered because of time constraints and the heavy caseloads in clinical work (Crawford, Allan & Jack, 1992). Crawford *et al.* (1992) proposed the use of a 4 subtest short-form which included Comprehension, Similarities, Block Design and Object Assembly and built regression equations to predict full-length Verbal, Performance and Full-Scale IQ from the age graded scores. This short-form has a reasonably high correlation with full-length IQ but more importantly has high construct validity as a measure of the 'verbal' and 'perceptual organisation' factors of the WAIS-R (Crawford, 1992). This was therefore the short-form employed in the current study. The subtests were administered in the following order to counterbalance the perceptual organisation and verbal tests: Block Design, Comprehension, Object Assembly, Similarities.

BLOCK DESIGN

This is a construction test in which the subject is presented with red and white blocks. Four or nine blocks are presented depending on the difficulty of the item. Each block has two red sides, two white sides and two half-red half-white sides divided along the diagonal. The task is to use the blocks to reproduce the design of two block constructions made by the examiner and seven designs printed in a booklet. The order of presentation differs from the order of difficulty.

COMPREHENSION

This test includes two types of open-ended questions: 13 test common sense judgement and practical reasoning, for example *'Why should people pay tax?'*, and the other 3 ask for the meaning of proverbs, for example, *'What does this saying mean? "Strike while the iron is hot."'* Comprehension items range in difficulty from common-sense answers to the much more difficult proverbs. Subjects score one or two points for each question depending on whether the answer is particular and concrete or general and abstract.

OBJECT ASSEMBLY

This test contains four cut-up cardboard figures of familiar objects given in order of increasing difficulty which include a mannequin, a profile, a hand and an elephant. All responses are scored for time and accuracy and subjects also receive credit for partially complete responses. There is a time limit on each item, two minutes for the first two and three for the last two items.

SIMILARITIES

This is a test of verbal concept formation where the subject must explain how each of a pair of words are alike. The word pairs range in difficulty from the simplest - *'orange-banana'* to the most difficult - *'praise-punishment.'* Subjects score one or two points for each question depending on whether the answer is a specific concrete likeness or an abstract generalisation.

Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975)

This brief screening instrument is used to detect significant acquired cognitive impairment and has been the most widely used mental status examination for dementia. The MMSE is a relatively quick and easily administered test, taking approximately five to ten minutes and tests a limited range of cognitive functions, for example, orientation for time and place, short-term memory and attention. A score out of a possible total of 30 is easily calculated, with scores below 24 considered abnormal for dementia and delirium screening.

Controlled Oral Word Association Test (Benton and Hamsher, 1989)

The present study included measures of current intellectual functioning that were thought to be sensitive to the effects of cerebral dysfunction (the Controlled Oral Word Association or 'Verbal Fluency' test and Stroop test) in addition to the WAIS-R. Verbal Fluency tests are widely used in the assessment of current cognitive impairment and are a good indicator of subtle residual impairments especially if there has been involvement of the frontal lobes (Lezak, 1995). This verbal fluency measure tests the oral production of spoken words beginning with a designated letter. The subject is asked to say as many words as they can think of that begin with a given letter of the alphabet (F, A & S) in three one-minute trials, but excluding proper nouns, numbers and the same word with a different suffix. The score, which is the sum of all acceptable words produced in the three trials, is adjusted for age, sex and education. Crawford, *et al.*, (1992) have recommended that premorbid ability is taken into account and have developed regression equations to predict verbal fluency scores on the basis of NART errors.

Stroop (Stroop, 1935; Trenerry et al, 1989)

This is a measure of attention/concentration and is again thought to be a sensitive indicator of subtle residual impairments and deficits in executive functioning. The subject is presented with a sheet with a series of 112 colour names printed in non-matching coloured inks. The first task is to name aloud the colour name. The second task is to name the colour of the ink used to print the words, not the colour name. The subject is given 120 seconds to name as many as possible.

2.4.4 Measures of Psychological Distress

Hospital Anxiety and Depression Scale (HAD; Zigmund & Snaith, 1983)

The HAD, which was devised as a brief screening test for the presence of anxiety and depression in non-psychiatric hospital patients, was used to assess the levels of self-reported psychological distress in the study participants. The scale consists of two 7-item subscales covering anxiety and depression, each item being rated on a 4-point scale. A total score of 21 is possible for each subscale, with 8-10 indicating 'borderline' levels and a cut-off of 11 or more indicating 'caseness'. The HAD has been found to be both reliable and valid (Zigmund & Snaith, 1983), and was designed in order to minimise the effects of concurrent physical illness on mood.

2.5 ANALYSIS OF DATA

2.5.1 Subject Confidentiality

To maintain subject confidentiality, each subject was assigned an identification number which was entered into the computer. Subjects names were removed from all interview schedules once the data had been collected leaving only these numbers. In addition, data were stored in a document which was password protected.

2.5.2 Data Analysis

Data were entered onto a Microsoft Excel Spreadsheet and analysed using the Statistical Package for the Social Sciences (SPSS) for Windows/ Student Version. The statistical analyses that were performed were guided by previous research which examined the relationship between premorbid measures of intellectual functioning and measures of current intellectual functioning. Each subject completed all assessments so there were no missing data. A significance level was set at $p<.05$.

Parametric statistics require that data meet the following assumptions:

- Each of the groups is an independent random sample from a normal population
- In the population, the variances of the groups are equal.

To ascertain whether parametric statistics could be employed to analyse the data, the Kolmogorov-Smirnov Goodness of Fit Test was used to determine whether the measures differed significantly from the normal distribution, while the Levene Test for Homogeneity of Variance was used to determine whether the measures came from populations with the same shared variance. All measures apart from the MMSE, Stroop and HAD Anxiety and Depression met the criteria necessary to enable the use of parametric statistics (see Appendix 2). When the non-parametric test results involving the MMSE, Stroop and HAD did not differ from parametric results, the parametric statistics were given.

The following statistical methods were therefore used to analyse the data according to the hypotheses set out in Section 1.3 above:-

Aim 1: Parametric statistics including Multivariate Analysis of Variance (MANOVA) were used to determine whether there were any significant differences between the groups on measures of premorbid and current levels of intellectual functioning and psychological distress. Analysis of Variance was also used to test the hypothesis that performance on the premorbid measures does not differ according to the severity of head injury sustained.

In addition, correlational techniques were used to test the hypothesis that performance on the premorbid measures would not be related to measures of head-injury severity,

Aim 2: Correlational techniques were used to investigate whether measures of premorbid intellectual functioning were related to measures of current intellectual functioning in the healthy control group.

Aim 3: A within subjects t-test was employed to test the hypothesis that subjects will perform better on the CCRT than the NART.

To test the hypothesis that subjects with poor or average reading ability will perform better on the CCRT than the NART, descriptive statistics and within subjects t-tests were employed.

Aim 4: Multiple linear regression techniques were used to determine whether the combination of demographic variables with premorbid measures would improve the amount of explained variance in predicted Full-Scale, Verbal and Performance IQ.

3. RESULTS

This chapter is split into 6 sections. The first provides additional data on the head-injured and orthopaedic control groups. The second describes the demographic characteristics of each of the three groups. Subsequent sections examine the hypotheses set out in section 1.3 above.

3.1 ADDITIONAL INFORMATION ON HEAD-INJURED AND ORTHOPAEDIC SAMPLES.

3.1.1 Head Injured Group

The severity of head-injuries sustained by this group as determined by the Glasgow Coma Scale (GCS) were as follows:

- 15 subjects (60%) sustained a Severe head-injury (GCS 3-8),
- 6 subjects (24%) sustained a Moderate head-injury (GCS 9-12),
- 4 subjects (16%) sustained a Mild head-injury (GCS 13-15).

The causes of head-injury were:

- 8 (32%) Assaults
- 13 (52%) Road Traffic Accidents
- 2 (8%) Falls whilst intoxicated
- 2 (8%) Accidents

The average time since sustaining the head-injury was 23.81 months (range 9.0-50.8 months).

3.1.2 Orthopaedic Control Group

The causes of injuries sustained by the orthopaedic sample were as follows:

- 10 (50%) Sporting Injuries
- 6 (30%) Road Traffic Accidents
- 4 (20%) Accidents

3.2 DEMOGRAPHIC CHARACTERISTICS

The demographic details of the three groups are presented in Table I.

Table I: Demographic Information (M=Means, SD=Standard Deviations and C.Intervals=Confidence Intervals).

	Healthy Controls (n=50)	***Head-Injured (n=25)***	***Orthopaedic Controls (n=20)***	***Statistic***	***Significance Level (p=)***
Anova :					
Age					
M (SD)	**30.16** (11.30)	**26.96** (9.14)	**34.00** (10.97)	F=2.40	p=.0962
C.Intervals	26.95 - 33.37	23.19 - 30.73	28.87 - 39.13		NS
Years Education					
M (SD)	**14.67** (2.38)	**11.89** (1.58)	**12.82** (2.48)	F=14.39	p<.001
C.Intervals	13.99 - 15.35	11.24 - 12.54	11.67 - 13.98		
Chi-Square:					
Sex (M/F)					
No.	26/24	20/5	18/2		
%	52/48	80/20	90/10	χ^2=11.85	p<.01
Social Class					
I	3	0	2		
II	19	5	6		
III	24	17	10	χ^2=7.72	p=.461
IV	4	2	1		NS
V	0	1	1		
Deprivation Category:-					
1	14	4	1		
2	7	4	4		
3	15	5	3		
4	6	11	6		
5	3	1	1	χ^2=19.53	p=.0765
6	0	0	1		NS
7	3	0	2		

NS=Not significant.

The data were analysed using an Analysis of Variance for independent groups (two-tailed). The head-injured and control groups did not differ significantly in terms of age ($F = 2.40$, $df = 2$, $p=.0962$), however there was a significant difference between the groups in years of education ($F = 14.39$, $df = 2$, $p<.001$). Post hoc Scheffe tests (pre-set at $p<.05$) indicated that the healthy controls were significantly better educated than the head-injured group.

Further analyses of the categorical data were carried out using Chi-Square analyses (with Fisher's exact test computed for tables which have a cell with an expected frequency of less than 5). Significant gender differences were found between the groups with the proportion of women being higher in the healthy normal control group than in the head-injured or orthopaedic control groups ($\chi^2 = 11.85$, $df = 2$, $p<.01$). There was no significant difference between the groups in terms of social class ($\chi^2 = 7.72$, $df = 8$, $p = .461$) or deprivation category ($\chi^2 = 19.53$, $df = 12$, $p = .0765$).

The results indicate, therefore, that the three groups were well matched in terms of age and maximal occupational history, but not so in terms of years of education or sex differences.

3.3 MEASURES OF PREMORBID AND CURRENT INTELLECTUAL FUNCTIONING

To assess whether there were any significant differences between the head-injured and control groups on measures of premorbid and current levels of intellectual functioning, the data were analysed using Multivariate Analysis of Variance (MANOVA), while Analysis of Variance was used to determine whether there were significant differences between the groups in levels of psychological distress. The results are shown in Table II(a,b&c).

Table IIa: Between Group Comparisons of Measures of Premorbid Intellectual Functioning

	Healthy Controls	*Head-Injured*	*Orthopaedic Controls*	*Univariate Statistic*	*Significance Level (p=)*
Premorbid Measures					
NART errors					
M (SD)	**19.34** (8.82)	**26.68** (8.66)	**22.50** (8.07)	F=6.08	p< .01
C.Intervals	16.83 - 21.85	23.10 - 30.26	18.72 - 26.28		
CCRT errors					
M (SD)	**16.30** (7.76)	**22.04** (7.46)	**18.80** (7.76)	F=4.69	p<.05
C.Intervals	14.09 - 18.51	18.96 - 25.12	15.17 - 22.43		
S-t-W errors					
M (SD)	**10.66** (5.17)	**13.96** (6.23)	**12.10** (4.84)	F=3.14	p<.05
C.Intervals	9.19 - 12.13	11.39 - 16.53	9.83 - 14.37		
Overall Manova:				F=2.13	p=.052 NS

Table IIb: Between Group Comparisons of Measures of Current Intellectual Functioning.

	Healthy Controls	***Head-Injured***	***Orthopaedic Controls***	***Univariate Statistic***	***Significance Level (p=)***
Current Measures:					
WAIS-R:					
FSIQ					
M (SD)	**110.82** (10.90)	**91.20** (9.15)	**105.05** (13.01)	F=26.77	p<.001
C.Intervals	107.72-113.92	87.42 - 94.98	98.96 - 111.14		
VIQ					
M (SD)	**104.62** (10.18)	**90.00** (8.42)	**99.80** (9.75)	F=19.09	p<.001
C.Intervals	101.72-107.51	86.52 - 93.48	95.24 - 104.36		
PIQ					
M (SD)	**110.44** (10.80)	**93.60** (10.78)	**106.05** (13.76)	F=18.06	p<.001
C.Intervals	107.37-113.51	89.15 - 98.05	99.61 - 112.49		
MMSE					
M (SD)	**29.42** (0.70)	**27.84** (2.15)	**29.05** (0.83)	F=13.01	p<.001
C.Intervals	29.22 - 29.62	26.95 - 28.73	28.66 - 29.44		
V.Fluency					
M (SD)	**43.76** (9.65)	**31.20** (8.88)	**41.10** (9.66)	F=14.91	p<.001
C.Intervals	41.02 - 46.50	27.53 - 34.86	36.58 - 45.62		
Stroop					
M (SD)	**107.26** (1.19)	**90.48** (17.45)	**101.60** (13.30)	F=15.27	p<.001
C.Intervals	104.87-109.65	83.28 - 97.68	95.37 - 107.83		
Overall Manova:				F=5.83	p<.001

Table IIc: Between Group Comparisons of Measures of Premorbid and Current Intellectual Functioning and Psychological Distress.

	Healthy Controls	***Head-Injured***	***Orthopaedic Controls***	***Statistic***	***Significance Level (p=)***
Psychological Distress:					
Anxiety *M (SD)* *C.Intervals*	**6.82** (3.21) 5.91 - 7.73	**8.16** (4.90) 6.14 - 10.18	**6.80** (2.80) 5.49 - 8.11	F=1.25	p=.2919 NS
Depression *M (SD)* *C.Intervals*	**3.28** (2.60) 2.54 - 4.02	**6.96** (4.71) 5.02 - 8.91	**3.40** (2.78) 2.10 - 4.70	F=11.14	p<.001

Initial appraisal of the results in Table IIa indicates that the difference between the groups on all measures of premorbid intellectual functioning (F = 2.13, df = 6, p = .052) was bordering on significance, while the univariate comparisons between the groups were all significant (NART; F=6.08, df=2,92, p<.01: CCRT; F=4.69, df=2,92, p<.05: StW; F=3.14, df=2,92, p<.05). The results in Table IIb also indicate that there was a significant difference between the groups on all measures of current intellectual functioning (F = 5.83, df = 12, p<.001). Table IIc shows that the head-injured and control groups did not differ significantly in levels of anxiety (F = 1.25, df = 2, p=.2919), however there was a significant difference between the groups in levels of depression (F = 11.14, df = 2, p<.001). Post hoc Scheffe test (pre-set at p<.05) indicated that the head-injured group were significantly more depressed than either the healthy controls or the orthopaedic controls.

It must be noted, however, that the between-group differences which emerged may be attributable to the significant differences which existed between the groups in terms of demographic variables such as years education and gender, and the significant difference in levels of depression. Years of education, but not gender differences, are known to be related to NART performance (Crawford *et al.*, 1988b). Correlations were therefore derived to look at the relationship between both years education and depression and the measures of premorbid and current intellectual functioning. Highly significant correlations were found between both years education and depression and the measures of premorbid and current intellectual functioning. Further, a significant negative correlation was found between years education and depression indicating that the fewer years education a person had completed, the more depressed they were. These results are shown in Table III.

Table III: Relationship between Years Education and Depression and the Measures of Premorbid and Current Intellectual Functioning (Pearson correlation coefficient [r=] and two-tailed significance, n=95).

	Years Education	***Depression***
Depression	-.4358 p<.001	1.00
NART Errors	-.5094 p<.001	.3294 p<.001
CCRT Errors	-.5129 p<.001	.3576 p<.001
S-t-W Errors	-.3960 p<.001	.3139 p<.01
WAIS-R FSIQ	.6098 p<.001	-.4413 p<.001
WAIS-R VIQ	.5857 p<.001	-.3508 p<.001
WAIS-R PIQ	.5028 p<.001	-.4224 p<.001
MMSE	.4031 p<.001	-.4089 p<.001
Verbal Fluency	.3094 p<.01	-.2968 p<.01
Stroop	.4099 p<.001	-.4148 p<.001

In order to control for these effects, a multivariate analysis of co-variance was carried out using the measures of premorbid and current intellectual functioning as dependent variables and years education, depression and gender as co-variates. The results of this analysis, including adjusted means, are shown in Table IV

Table IV: Between Group Comparisons of Measures of Premorbid and Current Intellectual Functioning and Psychological Distress controlling for the effects of Years Education, Gender and Depression (Mean adjusted scores).

	Healthy Controls	***Head-Injured***	***Orthopaedic Controls***	***Statistic (F=)***	***Significance Level (p=)***
Premorbid Measures:					
NART errors	22.21	24.17	22.14	.4356	p=.648 NS
CCRT errors	18.98	19.53	18.64	.0816	p=.992 NS
S-t-W errors	12.32	12.49	11.92	.0651	p=.937 NS
Overall Manova				.6515	p=.689 NS
Current Measures:					
WAIS-R:					
FSIQ	107.49	94.70	104.88	10.70	p<.001
VIQ	101.66	92.50	100.25	6.86	p<.01
PIQ	108.02	96.73	105.34	6.74	p<.01
MMSE	29.08	28.17	29.07	3.87	p<.05
V.Fluency	43.23	32.15	40.68	8.21	p<.001
Stroop	104.97	93.48	100.88	5.37	p<.01
Overall Manova				2.65	p<.01

The results indicate that, after controlling for the effects of years education, gender and depression, no significant differences remained between the groups on any of the measures of premorbid intellectual functioning ($F = .6515$, $df = 6$, $p = .689$), however statistically significant differences remained between the groups on all measures of current intellectual functioning (F = 2.66, df = 12, p<.01). Post hoc Scheffe test revealed that the head-injured groups' scores on all of the measures of current intellectual functioning were significantly lower than both the healthy controls and the orthopaedic controls.

It is interesting to note, however, that depression was no longer correlated with any of the measures of premorbid intellectual functioning when the difference in years education had been controlled for (see Appendix 3), although significant differences in depression remained between the groups (as in Table IIc).

Further analyses were performed to test the hypothesis that performance on the premorbid measures does not differ according to the severity of head injury sustained (determined by the Glasgow Coma Scale - GCS). Individuals with a GCS total score of 3-8 were classified as having "severe" injuries; 9-12 "moderate" and those with a GCS of 13-15 were classified as having "mild" injuries. The results are shown in Table V.

Table V: Performance on Measures of Premorbid Intellectual Functioning by the Head-Injured Group.

	Severity of Head-Injury			***Value (F=)***	***Significance Level (p=)***
	Mild *(n=4)*	***Moderate*** *(n=6)*	***Severe*** *(n=15)*		
Premorbid Measures:					
NART errors					
M (SD)	**21.75** (7.63)	**28.67** (8.48)	**27.20** (9.03)	F=.8199	p=.4535
C.Intervals	9.60 - 33.89	19.77-37.56	22.20-32.20		NS
CCRT errors					
M (SD)	**17.50** (5.74)	**24.00** (7.10)	**22.47** (7.92)	F=.9689	p=.3951
C.Intervals	8.35 - 26.64	16.55-31.45	18.08-26.85		NS
S-t-W errors					
M (SD)	**10.75** (4.11)	**15.00** (6.20)	**14.40** (6.76)	F=.6309	p=.5414
C.Intervals	4.21 - 17.29	8.50 - 21.50	10.65-18.14		NS

The data were analysed using an Analysis of Variance for independent groups (two-tailed). Although the moderate and severely head-injured subjects appeared to make more errors on the premorbid measures than those who sustained a mild head-injury, the results in Table V indicate that there were no significant differences between the groups on any of these measures.

Correlational techniques were then used to test the hypothesis that performance on the premorbid measures is unaffected by head-injury and is not therefore related to measures of head-injury severity. The data were analysed using Spearman Rank Correlations as the measure of head-injury severity (GCS) was ordinal in nature. The results are shown in Table VI.

Table VI: Correlation Coefficients of Severity of Head-Injury and Premorbid Intellectual Functioning in the Head-Injured Group (Spearman Correlation Coefficient [r_s] and two-tailed significance, n=25).

	NART Errors	***CCRT Errors***	***Spot-the-Word Errors***
Glasgow Coma Scale (GCS)	-.1458 p=.487 (NS)	-.1763 p=.399 (NS)	-.1857 p=.374 (NS)

The results in Table VI indicate that the none of the measures of premorbid intellectual functioning are significantly correlated with measures of head-injury severity.

It would appear, then, that the hypothesis that there will be no significant differences between the head-injured group and the control groups on the premorbid measures of intellectual functioning (NART, CCRT, Spot-the-Word) irrespective of their severity of head-injury, has been supported by the data. Further, the hypothesis that the head-injured subjects will perform significantly more poorly on measures of current intellectual functioning (WAIS-R, MMSE, Verbal Fluency, Stroop) has also been supported by the data. Depression, however, emerged as a potentially important confounding variable. Finally, the hypothesis that subjects' performance on measures of premorbid intellectual functioning is unaffected by head-injury has been supported by the data.

3.4. CORRELATIONS BETWEEN PREMORBID AND CURRENT INTELLECTUAL FUNCTIONING.

To ascertain whether the measures of premorbid intellectual functioning provide a valid estimate of current intellectual functioning, the NART, CCRT and Spot the Word tests were correlated with measures of current intellectual functioning in the healthy control group using Pearson Product Moment Correlations. Correlations were also derived to look at the relationship between the premorbid measures themselves - the CCRT and Spot-the Word were correlated with the NART to assess whether they are valid premorbid measures. The results are shown in Table VII.

Table VII: Relationship between Measures of Premorbid and Current Intellectual Functioning in the Normal Control Group (Pearson Correlation Coefficient [r] and two-tailed significance, n=50).

	NART Errors	***CCRT Errors***	***Spot-the-Word Errors***	***WAIS-R Full Scale IQ***	***WAIS-R Verbal IQ***	***WAIS-R Perf. IQ***
NART Errors	1.00	.9692 p<.001	.8160 p<.001	-.5650 p<.001	-.7869 p<.001	-.1841 p=.201 NS
CCRT Errors	.9692 p<.001	1.00	.8100 p<.001	-.6144 p<.001	-.8162 p<.001	-.2326 p=.104 NS
Spot-the-Word Errors	.8160 p<.001	.8100 p<.001	1.00	-.4917 p<.001	-.6436 p<.001	-.1892 p=.188 NS

The results show that the three measures of premorbid intellectual functioning are highly significantly correlated with WAIS-R Full-Scale and Verbal IQ, but are not significantly correlated with WAIS-R Performance IQ. Of the premorbid measures, the CCRT was the most highly correlated with Full-Scale and Verbal IQ ($r = -.6144$, $p<.001$; $r = -.8162$, $p<.001$ respectively), and predicted 38%, 67% and 5.4% of the variance in WAIS-R Full-Scale, Verbal and Performance IQ respectively. The NART was more highly correlated with Full-Scale and Verbal IQ than the Spot-the-Word ($r = -.5650$, $p<.001$; $r = -.7869$, $p<.001$ respectively), predicting 32%, 62% and 3.4% of the variance in WAIS-R Full-Scale, Verbal and Performance IQ respectively. The Spot-the-Word had the lowest correlation with Full-Scale and Verbal IQ ($r = -.4917$, $p<.001$; $r = -.6436$, $p<.001$), and predicted only 24%, 41% and 3.5% of the variance in WAIS-R Full-Scale, Verbal and Performance IQ. The relationship between Verbal IQ and the CCRT, NART and Spot-the-Word is shown in Figures 1, 2 and 3 respectively.

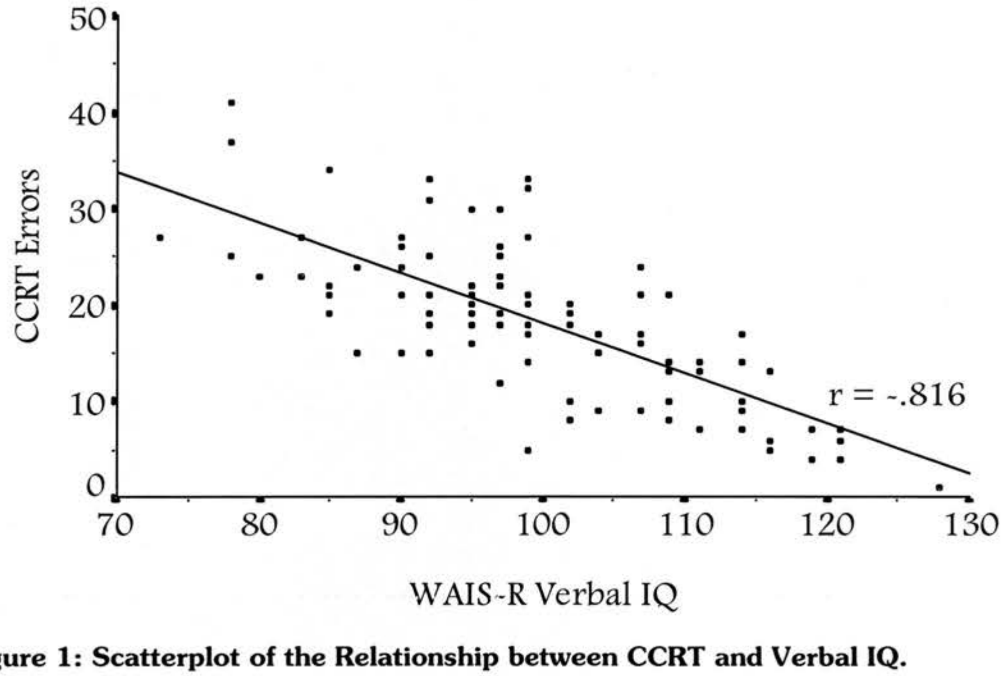

Figure 1: Scatterplot of the Relationship between CCRT and Verbal IQ.

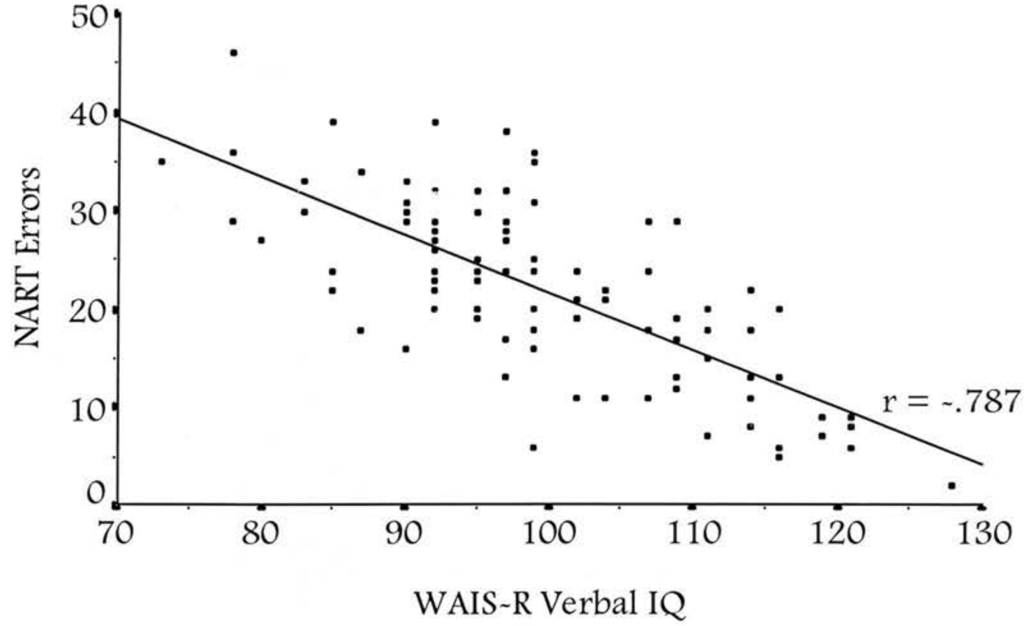

Figure 2: Scatterplot of the Relationship between NART and Verbal IQ.

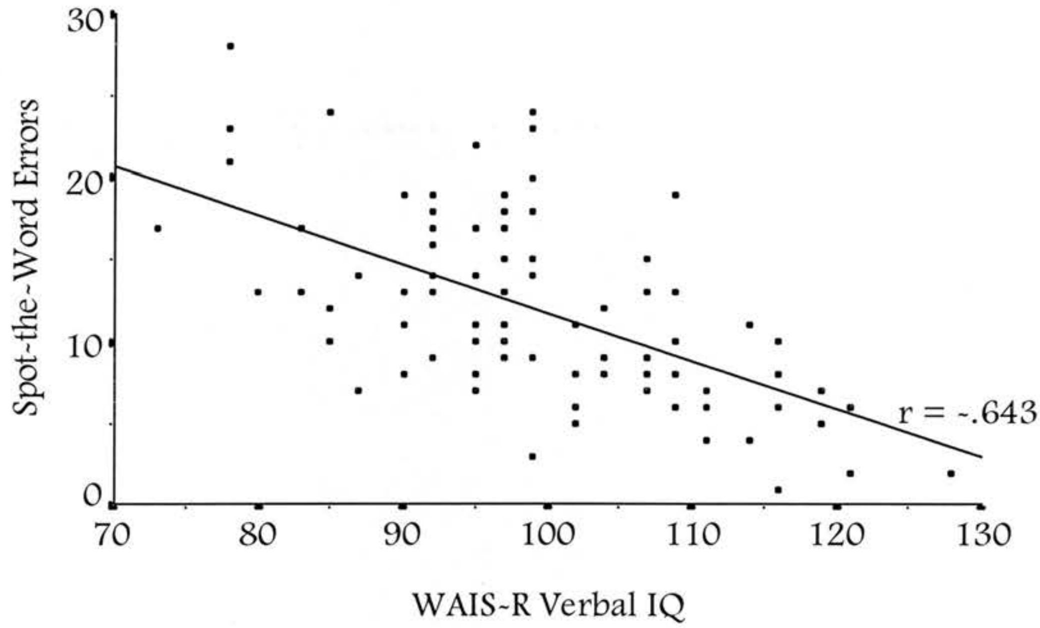

Figure 3: Scatterplot of the Relationship between Spot-the-Word and Verbal IQ.

Further perusal of the results in Table VII indicates that the premorbid measures are all significantly correlated with each other. The NART and CCRT were highly significantly correlated (r = .9692, p<.001). The Spot-the-Word was also highly correlated, although to a lesser degree with the NART ($r = .8160$, $p<.001$) and the CCRT ($r = .8100$, $p<.001$). The correlation between the Spot-the-Word and the NART was only marginally better than that with the CCRT.

In summary, it is evident from the results above that the hypothesis that the NART, CCRT and Spot the Word tests will correlate with measures of current intellectual functioning in the healthy control group has, in the main, been supported by the data. The CCRT and NART were shown to be more highly correlated with current intelligence than the Spot-the-Word Test. Further, evidence has been presented supporting the hypothesis that the CCRT and Spot-the Word should correlate highly with the NART if they are valid premorbid measures of intellectual functioning.

3.5. Comparison of Performance on the NART and CCRT.

To ascertain whether reading ability is improved by context, subjects' performance on the NART was compared with their performance on the CCRT using within subjects t-tests. The results are presented in Table VIII.

Table VIII: Group Comparisons of Performance on the NART and CCRT (Mean, (Standard Deviation) and Differences between Scores).

	NART errors	***CCRT errors***	***Difference*** *(& C.Intervals)*	***t-value***	***Significance Level (p=)***
Normal Controls (n=50)	**19.34** (8.82)	**16.30** (7.76)	**3.04** (2.31) 2.38 - 3.70	9.30	$p<.001$
Head-Injured (n=25)	**26.68** (8.66)	**22.04** (7.46)	**4.64** (4.48) 3.62 - 5.66	9.35	$p<.001$
Orthopaedic Controls (n=20)	**22.50** (8.07)	**18.80** (7.76)	**3.70** (2.90) 2.34 - 5.06	5.70	$p<.001$

The results indicate that, in each of the groups studied, subjects made significantly fewer errors on the CCRT than the NART. Indeed, the normal control group demonstrated a significant mean improvement of 3.04 words on the CCRT ($t = 9.30$, $df = 49$, $p<.001$), the head-injured group showed a mean improvement of 4.64 words on the CCRT ($t = 9.35$, $df = 24$, $p<.001$), and the orthopaedic control group showed a mean improvement of 3.70 words on the CCRT ($t = 5.70$, $df = 19$, $p<.001$). An analysis of variance comparing the healthy and orthopaedic control groups and the head-injured group revealed that there was a significant difference in improvement between the three groups ($F = 3.464$, $df = 2$, $p<.05$), with post-hoc Scheffe tests indicating that the head-injured group benefited more from context than the healthy control group.

The results obtained by analysing mean group performance are amplified in Table IX, which presents the percentage of individuals within each group who benefited or failed to benefit from the CCRT.

Table IX: Comparison of NART and CCRT Errors (Percentage).

	CCRT better than NART *(CCRT errors < NART errors)*	***CCRT worse than NART*** *(CCRT errors > NART errors)*	***CCRT equal to NART*** *(CCRT errors = NART errors)*
Normal Controls (n=50)	90%	2%	8%
Head-Injured (n=25)	100%	0	0
Orthopaedic Controls (n=20)	80%	5%	15%
Total (n=90)	90.53%	2.10%	7.37%

The results in Table IX demonstrate that the vast majority of subjects - 90.53% - performed better on the CCRT than the NART, thus showing improved contextual word reading as compared to single-word reading. Only 2.1% of the total sample managed to correctly pronounce more words when they were presented in the traditional NART format as opposed to the CCRT, while 7.37% showed no difference between the measures. Each subject in the head-injured group (100%) performed better on the CCRT than on the NART compared with 90% of the healthy control group and 80% of the orthopaedic control group.

To address the question of whether poor/average readers benefit more from context than do good readers, the control groups were divided into three subgroups according to performance on the first half of the NART. Groups were defined following those of Beardsall & Brayne (1990), with poor readers scoring 0-11; average readers scoring 12-20 and good readers scoring above 20. Further, to determine whether subjects with more severe head-injuries benefited more from context, the head-injured group was divided according to severity of head-injury. The results are shown in Table X. Information on education levels of the subgroups is shown in Appendix 4.

Chi-square analysis revealed that the normal control group and orthopaedic control group did not differ significantly in terms of the amount of good, average and poor readers within the sample (χ^2 = .526, df = 2, p = .769; NS). The data were then analysed using within subjects t-tests (two-tailed). The results in Table X indicate that all subjects in the healthy normal control and orthopaedic control groups, irrespective of reading ability, scored significantly fewer errors on the CCRT - thus improving their pronunciation performance. The data indicate, however, that the average readers benefited most from context, with a mean improvement on the CCRT over the NART in the healthy control group of 4.00 words read correctly and in the orthopaedic controls of 5.62 words read correctly. Good readers benefited by an additional 2.33 and 2.73 words read correctly when words were seen in context in the healthy control and orthopaedic control groups respectively. It was not possible to comment on the effect of context on poor readers because of the small number in each group. Analysis of variance revealed that there was a significant difference between the three subgroups in terms of improvement on the CCRT over the NART

Table X: Subgroup Comparisons of Performance on the NART and CCRT (Mean, (Standard Deviation) and Differences between Scores).

	NART errors	*CCRT errors*	*Difference* *(& C.Intervals)*	*t-value*	*Significance Level (p=)*
Normal Controls:					
Good readers (n=30)	**13.73** (6.06)	**11.40** (5.13)	**2.33** (1.99) 1.59-3.08	6.43	p<.001
Average readers (n=19)	**27.16** (3.80)	**23.16** (4.07)	**4.00** (2.43) 2.83-5.17	7.18	p<.001
Poor readers (n=1)	**39.00**	**33.00**	**6.00**	*	*
Head-Injured					
Mild (n=4)	**21.75** (7.63)	**17.50** (5.74)	**4.25** (2.87) 0.32-8.82	2.96	p=.060 NS
Moderate (n=6)	**28.67** (8.48)	**24.00** (7.10)	**4.67** (2.58) 1.96-7.38	4.43	p<.01
Severe (n=15)	**27.20** (9.03)	**22.47** (7.92)	**4.73** (2.52) 3.34-6.13	7.27	p<.001
Orthopaedic Controls					
Good readers (n=11)	**16.36** (3.98)	**13.64** (4.08)	**2.73** (2.57) 0.99-4.46	3.52	p<.01
Average readers (n=8)	**29.25** (4.10)	**23.62** (4.87)	**5.62** (2.13) 3.84-7.41	7.46	p<.001
Poor readers (n=1)	**36.00**	**37.00**	**-1.00**	*	*

* = Analysis cannot be performed as only 1 case in cell.

in both the healthy control group ($F = 4.39$, $df = 2$, $p<.05$) and the orthopaedic control group ($F = 5.39$, $df = 2$, $p<.05$). Post-hoc Tukey tests indicated that the average readers benefited more than did the good readers. Table X also shows that the mild, moderate and severe head-injured groups benefited from the contextual information available in the CCRT, improving their performance by 4.25, 4.67 and 4.73 words respectively. This difference was significant in the moderate and severe groups ($t = 4.43$, $df = 1$, $p<.01$; $t = 7.27$, $df = 1$, $p<.001$ respectively) while the benefit to the mild head injured group showed a trend towards significance ($t = 2.96$, $df = 1$, $p=.06$). Analysis of variance revealed no significant differences in improvement between the subgroups in terms of severity of head injury sustained ($F = .0556$, $df = 2$, $p = .9460$, NS).

In summary, it is evident from the results presented above that the hypothesis that subjects will perform better on the CCRT than the NART, thereby showing improved contextual word reading as compared to single-word reading, has been supported by the data. Further, the hypothesis that subjects with a head-injury or with average reading ability will benefit more from the inclusion of contextual cues than those with good reading ability has, in the main, been supported by the data.

3.6. COMBINING PREMORBID MEASURES AND DEMOGRAPHIC VARIABLES.

In order to determine whether the addition of demographic variables to the NART, CCRT and Spot the Word would improve the amount of explained variance in predicted Full-Scale IQ, Verbal IQ and Performance IQ, multiple linear regression analyses were undertaken using the same protocol adopted by Crawford *et al.,* (1989e). Using a stepwise procedure, WAIS-R Full-Scale, Verbal and Performance IQ were individually regressed on the premorbid measures - either NART errors, CCRT errors or Spot-the-Word errors - and years education, social class, age, sex and deprivation category. Sex was dummy variable coded with males = 1, females = 2 (Coven & Coven, 1983). The results of this procedure are shown in Table XI.

Table XI: Results of Stepwise Multiple Regression of WAIS-R Scales on the Premorbid Measures and Demographic Variables (n=50)

	Multiple R	*R^2 (Amount of Variance Predicted)*	*Significance of R^2 change**
Full-Scale IQ			
NART & Demogs			
Step 1: NART	.565	.319	p<.001
Step 2: Yrs Education	.618	.382	p<.001
CCRT & Demogs			
Step 1: CCRT	.614	.378	p<.001
Step 2: Yrs Education	.654	.428	p<.001
S-t-W & Demogs			
Step 1: Spot-the-Word	.492	.242	p<.001
Step 2: Yrs Education	.609	.371	p<.001
Verbal IQ			
NART & Demogs			
Step 1: NART	.787	.619	p<.001
Step 2: Social Class	.832	.692	p<.001
CCRT & Demogs			
Step 1: CCRT	.816	.666	p<.001
Step 2: Social Class	.853	.727	p<.001
S-t-W & Demogs			
Step 1: Social Class	.713	.508	p<.001
Step 2: Spot-the-Word	.833	.693	p<.001
Performance IQ			
NART & Demogs			
Step 1: Yrs Education	.307	.094	p<.05
CCRT & Demogs			
Step 1: Yrs Education	.307	.094	p<.05
S-t-W & Demogs			
Step 1: Yrs Education	.307	.094	p<.05

* Significance of change tested by applying F test to the change in the residual sums of squares at each step.

It can be seen from the results in Table XI that the addition of demographic variables to the premorbid measures in the regression equations increased the amount of variance predicted (R^2) for the WAIS-R Full-Scale and Verbal IQ scales. To determine whether this increase was statistically significant, analysis of variance (*F*) tests were performed on the change in the residual sum of squares following entry of the demographic variables. For both WAIS-R Full Scale and Verbal IQ scales, there was a significant increase in variance predicted ($p<.001$). It is interesting to note, however, that although five demographic variables were entered into the analysis, it was only one variable that significantly contributed to the amount of variance explained, the others becoming non-significant. Years education was the demographic variable that significantly contributed to the variance in WAIS-R Full-Scale IQ, while social class significantly contributed to the variance in Verbal IQ.

In the analysis performed on the WAIS-R Performance IQ scale, the demographic variables alone significantly contributed to the explained variance ($p<.05$), while the premorbid measures made no further significant contribution.

More specific appraisal of the regression analyses revealed that the CCRT was the single best predictor of Full-Scale and Verbal IQ and accounted for 38% and 67% of the variance respectively. The addition of demographic variables into the equation (years education into Full-Scale IQ equation and social class into the Verbal IQ equation) significantly increased the amount of explained variance ($F=17.56$, $df=2$, $p<.001$) & ($F=60.01$, $df=2$, $p<.001$), the combination accounting for 43% and 73% of the variance in Full-Scale IQ and Verbal IQ respectively. No other demographic variables significantly contributed to the explained variance.

The same analyses were performed using the NART, which produced a similar pattern to that of the CCRT. The NART was found to account for 32% and 62% of the variance in WAIS-R Full-Scale and Verbal IQ, slightly less than the variance accounted for by the CCRT. Again, the addition of demographic variables into the equation (years education into Full-Scale IQ equation and social class into the Verbal IQ equation) significantly increased the amount of explained variance ($F=13.93$, $df=2$, p<.001) & (F=50.65, df=2, p<.001), the combination accounting for 38% and 69% of the variance in Full-Scale IQ and Verbal IQ respectively. Again, the combination accounted for slightly less of the variance accounted for by the CCRT.

The results in Table XI show that the Spot-the-Word accounted for the least of the variance of all the premorbid measures, accounting for 24% of the variance in Full-Scale IQ. The addition of years education into the equation significantly increased the amount of explained variance to 37% (F=13.29, df=2, p<.001). Unlike the other premorbid measures, however, in the Verbal IQ equation, social class accounted for more of the variance in Verbal IQ than the Spot-the-Word (r= -.713 (51%) compared to r= -.644 (41%) respectively). Social class was therefore entered first into the equation, with Spot-the-Word entered second. The addition of Spot-the-Word did significantly contribute to Verbal IQ, increasing the amount of variance predicted by this equation to 69% (F=50.89, df=2, p<.001).

When stepwise regression analyses were performed on the WAIS-R Performance IQ scale, the same pattern emerged for each of the three premorbid measures. The premorbid measures alone did not significantly contribute to the amount of explained variance and therefore had to be excluded from the stepwise analysis. Years education alone was found to significantly contribute to the explained variance (F=4.78, df=1, p<.05), accounting for only 9.4% of the variance in Performance IQ. No other demographic variable or premorbid measure contributed to the amount of explained variance above and beyond this.

To determine the predictive accuracy of the demographic equations alone, the regression procedure was repeated with the premorbid measures excluded from the analysis. The regression procedure was also repeated with the demographic variables excluded from the analysis, leaving premorbid measures alone to examine their predictive accuracy. While some of this information could be extracted from the results of the regression analysis which combined demographic variables with the premorbid measures in Table XI, the information required was not complete, hence the supplementary analyses. The results are summarised in Table XII.

Table XII: Amount of Variance accounted for by Three Methods of Prediction

	Demographics Alone	***Premorbid Measures Alone***			***Combination of Demographics &***		
		NART	***CCRT***	***S-t-W***	***NART***	***CCRT***	***S-t-W***
FSIQ: % variance	**32**	**32**	**38**	**24**	**38**	**43**	**37**
VIQ: % variance	**61**	**62**	**67**	**41**	**69**	**73**	**69**
PIQ: % variance	**9.4**	**3.4**	**5.4**	**3.6**	**9.4**	**9.4**	**9.4**

It can be seen from Table XII that the combination of NART and demographic variables predicts 6% and 7% more Full-Scale and Verbal IQ variance than the NART alone and only 6% and 8% more variance than the corresponding demographic equations. The combination of the CCRT and demographic variables predicts 5% and 6% more variance in Full-Scale and Verbal IQ respectively than the CCRT alone but predicts 11% and 12% more variance than the corresponding demographic equations. Finally, the combination of demographic variables and Spot-the-Word predicts 13% and 28% more Full-Scale and Verbal IQ variance than the Spot-the-Word alone and only 5% and 8% more variance than the corresponding demographic equations. The demographic equations alone accounted for 32% and 61% of the variance in WAIS-R Full-Scale and Verbal IQ, with only two variables - years education and age and social-class and age - significantly contributing to Full-Scale IQ and Verbal IQ respectively.

As already indicated, the CCRT was the single best predictor of WAIS-R Full-Scale and Verbal IQ followed by the NART. The NART and demographic variables alone predicted similar amounts of the variance in Full-Scale and Verbal IQ. The Spot-the-Word alone was the worst single predictor of Full-Scale and Verbal IQ and did not even predict as much of the variance as the demographic method alone. The combination of CCRT and demographic variables was the overall best predictor of Full-Scale and Verbal IQ, while the combination of the NART or Spot-the-Word and demographics were virtually equivalent.

The premorbid measures (NART, CCRT and Spot-the-Word) were found to account for only 3.4%, 5.4% and 3.6% of the variance in Performance IQ. This information was not available from the stepwise analysis as these measures did not significantly contribute to the explained variance. The demographic variables were shown to be the overall best predictor of WAIS-R Performance IQ with years education being the only variable to significantly contribute to the explained variance.

In summary, it has been shown that the hypothesis that the addition of demographic variables to the NART, CCRT and Spot the Word will improve the amount of explained variance in predicted WAIS-R Full-Scale IQ and Verbal IQ has been supported by the data. The combination of CCRT and demographic variables was found to be the overall best predictor of WAIS-R Full-Scale and Verbal IQ. The hypothesis that the addition of demographic variables to the premorbid measures would increase the amount of variance explained in Performance IQ has not been supported by the data, with the demographic variables alone being the overall best predictor.

4. DISCUSSION

The introduction to this study stated that reliable and meaningful methods for determining premorbid intellectual levels of patients with closed head-injury were essential to aid in the evaluation of intellectual deterioration, in establishing treatment and rehabilitation goals and in resolving medico-legal issues, and argued that further research into the assessment of premorbid intellectual functioning in closed head injury was overdue. Indeed, in contrast to the wealth of literature on the use of the National Adult Reading Test in estimating the premorbid abilities of patients with dementia, there has been very little research into its use in closed head injury. Further, it was argued that the use of recently developed alternative measures of estimating premorbid intellectual functioning in dementia, such as the Cambridge Contextual Reading Test and Spot-the Word test, needed to be examined in other clinical conditions such as closed head-injury.

The aim of the present study was therefore to compare the performance of head injured subjects with two control groups - a non head-injured orthopaedic trauma control group and a healthy non-traumatised control group - on three measures of premorbid ability - the NART, CCRT and Spot the Word test. In order to achieve this aim a number of hypotheses were proposed. The first section of this discussion will provide a summary of the hypotheses and main findings from the results. The second section will examine each of the hypotheses in turn. Finally, the limitations of the current study will be highlighted and conclusions and future directions discussed.

4.1 SUMMARY OF MAIN FINDINGS

1. It was hypothesised that there should be no significant differences between the head-injured group and the control groups on the measures of premorbid intellectual functioning (NART, CCRT, Spot-the-Word) irrespective of their severity of head-injury, whereas the head-injured subjects were expected to perform significantly more poorly on measures of current intellectual functioning (WAIS-R, MMSE, Verbal Fluency, Stroop). This hypothesis was supported by the data. Depression, however, emerged as a potentially important confounding variable.

Further, measures of head-injury severity were not found to be related to performance on the premorbid measures, supporting the hypothesis that subjects' performance on the measures of premorbid abilities is unaffected by head-injury.

2. It was hypothesised that the NART, CCRT and Spot the Word tests would correlate with measures of current intellectual functioning in the healthy control group and thus provide a valid estimate of current intellectual functioning. This hypothesis was, in the main, supported by the data, with the CCRT and NART being shown to be more highly correlated than the Spot-the-Word Test. It was also expected that the CCRT and Spot-the Word would correlate highly with the NART if they were valid measures of premorbid intellectual functioning and evidence was presented to support this hypothesis

3. Head injured and control subjects showed improved contextual word reading as compared to single-word reading - improving their pronunciation performance on the CCRT (when words are seen in context) in comparison to their performance on the NART. This supports the hypothesis that reading ability is improved by context.

   It was hypothesised that subjects with a head injury or with poor or average reading ability would benefit more from the inclusion of contextual cues than those with good reading ability. This hypothesis was, in the main, supported by the data, however, it was not possible to conclusively demonstrate that poor readers benefited from context due to the small numbers in the poor reading group.

4. Finally, it was hypothesised that the addition of demographic variables to the NART, CCRT and Spot the Word would to improve the amount of explained variance in predicted WAIS-R Full-Scale, Verbal and Performance IQ. This hypothesis was partly supported by the data. The addition of demographic

variables to the premorbid measures was found to improve the amount of explained variance in predicted WAIS-R Full-Scale IQ and Verbal IQ but did not increase the explained variance in predicted Performance IQ.

These findings will be discussed in more detail below.

4.2. HYPOTHESES

4.2.1 Comparison of Performance on Measures of Premorbid Intellectual Functioning.

The key assumption on which measures of premorbid intellectual abilities is based is that they remain relatively unaffected by conditions which impair other cognitive functions. Thus the danger in using any current ability measure for this purpose is that the 'true' premorbid IQ will be underestimated if a client's performance on the test has suffered impairment. One method of evaluating premorbid measures is to conduct a simple comparison between the head-injured group and control groups. This method was adopted in the current study. The results of this study have shown that the performance of subjects with closed head-injury on the premorbid measures did not differ significantly from either control group once potentially confounding demographic variables had been controlled for. The finding that performance on neither the NART nor the CCRT was detrimentally affected suggests, therefore, that the oral pronunciation of irregular words is an ability which is unaffected by closed head injury. This indicates that these measures have validity as a measure of premorbid IQ in this condition.

These findings are consistent with two previous studies. In a study by Crawford *et al*, (1988), closed head-injury patients did not differ significantly from matched control subjects on their performance on the NART. Further, Moss & Dowd (1991) documented the case of a man who had sustained a severe head-injury on whom an intelligence test had been administered beforehand and demonstrated that the NART produced a very accurate estimate of his pre-injury IQ. No previous studies have looked at the utility of the CCRT in head-injury, however this study provides encouraging evidence of its validity as a measure of premorbid functioning.

The finding that performance on the Spot-the-Word test showed no evidence of decline in closed head-injury suggests that the test is relatively resistant to the effects of brain damage and indicates that it may hold considerable promise as a brief and simple means of estimating premorbid intelligence. This appears to be one of the first studies to demonstrate that the Spot-the-Word is indeed resistant to acquired organic impairment and is consistent with that of Baddeley *et al,* (1993) who showed that performance on the Spot-the-Word does not decline in elderly subjects with intellectual deterioration merely implied on the basis of high vocabulary and low fluid intelligence scores. Thus the preliminary evidence gives credence to the hypothesis of Baddeley *et al,* (1993) that lexical decision making, whereby a task can be successfully performed via a number of different routes, is not likely to be affected by brain damage.

Further evidence that the NART, CCRT and Spot-the-Word have validity as a measure of premorbid IQ in head-injury is provided by the fact that there were no significant differences in performance on these measures irrespective of the severity of head-injury sustained (determined by the Glasgow Coma Scale). Thus, had performance on these measures been affected by the severity of head-injury, it would have been expected that those with a more severe head-injury would score more errors on the premorbid measures than those with a moderate or mild head-injury. That this was not the case suggests that the three tests 'hold' when a mild, moderate or severe head-injury is sustained. Although there was very little difference in scores between the moderate and severely head-injured subjects, they appeared to make more errors on the premorbid measures than those with mild head-injuries. There were, however, no significant differences in performance between these groups. Indeed, the small numbers in the mild and moderate groups limits the conclusions that can be drawn and raises questions as to the generalisability of this finding. It may be that the trend demonstrated does indicate that the measures are vulnerable to the effects of more severe head-injuries, however this would need to be confirmed through replication on a larger sample.

It must be noted, however, that significant differences in performance on the premorbid measures were evident between the head-injured and control groups before demographic variables and depression had been controlled for. It is important to determine why this may be the case. The groups in this study were well matched in terms of age and social class (maximal occupational history) but were not found to be particularly well matched in terms of years of education or gender differences. Demographic variables are known to be related to IQ test performance (Matarazzo, 1972). Crawford *et al.*, (1988b) examined the relationship between demographic variables and NART performance and found that years of education was significantly correlated with NART estimated IQ but there were no significant gender differences in NART performance. It is therefore important to take adequate account of premorbid demographic variables known to be related to IQ test performance when analysing results in order that erroneous conclusions are not reached. Had these factors not been taken into consideration in the present study, it may have been wrongly concluded that performance on the premorbid measure was, in fact, detrimentally affected by head-injury.

The Role of Depression

It is also important to consider the role of depression in performance on the measures of premorbid functioning. Significant differences were found between the head-injured and control groups in levels of depression, with the head-injured group being significantly more depressed than either the healthy control or orthopaedic control groups. Depression was also found to be significantly correlated with measures of premorbid and current intellectual functioning. The more depressed a person was the more errors were made on the premorbid measures.

When the difference in years education had been taken into account, however, depression was no longer correlated with any of the measures of premorbid intellectual functioning, although significant differences in depression remained between the groups. Further, a significant negative correlation was found between years education and depression indicating that the less years education a person had, the more depressed they were. It is important to determine why this may be the case.

The fact that the head-injured group is significantly more depressed than the control groups is not in itself surprising. Numerous studies have shown that head-injured patients frequently experience emotional difficulties after head-injury, and depression is common (Gainotti, 1993; Brooks & McKinlay, 1983) - often increasing in intensity with time (Prigatano, 1992).

The fact that depression and years education are related and that depression was no longer correlated with any of the measures of premorbid intellectual functioning once years education had been controlled for is of more importance, and a number of alternative explanations are possible.

The first is that depression may in fact cause subjects to perform more poorly on the measures of premorbid ability, mediating between years education and performance. Thus the fact that years education and depression are related, with the fewer years of education completed, the more depressed a person is likely to be, may indicate that someone with a genuinely low premorbid ability is more likely to develop depression after a head-injury and thus perform more poorly on the premorbid measures. Education may therefore serve as a protective factor against depression with those that have less possibly having less adaptive coping resources at their disposal.

Depression following a head-injury is affected by a number of factors - neurological factors from the injury itself, psychological factors and psychosocial factors (Gainotti, 1993). Neurological factors are those factors which can provoke emotional disturbances by disrupting those specific neural mechanisms that subserve the regulation and control of emotional behaviour. Depression can result from disruption of the limbic system or structures linked with it as this system is involved in the regulation of emotional and social behaviour. Hemispheric differences have also been reported for the emotional changes accompanying head-injury, and it has been suggested that left hemisphere lesions can provoke a 'major' depression (Gainotti, 1993; Starkstein & Robinson, 1989). Psychological factors are those personal attitudes towards the disability that result from a full awareness of the implications it has for the persons quality of life, while psychosocial factors are the consequences that impairments will have on the social relationships and social activities of the patient. Depression as a result of any of these factors may therefore interfere with the normal expression of cognitive abilities and can complicate the clinical presentation in head-injury (Lezak, 1995). Most studies have looked at memory functions in depressed patients and impairments have been found in retrieval of both verbal and visuospatial material. This has been shown to reflect insufficient effort although memory processes themselves remain intact. This is an important issue when assessing premorbid abilities using the NART and CCRT, as poor performance may reflect a lack of effort in retrieving previously stored information and may result in an underestimate of premorbid functioning.

Another possible explanation is that depression has nothing to do with performance on the premorbid measures and it is years education alone which accounts for poorer performance on the premorbid measures. Thus the less education a person has, the lower their premorbid ability and hence the more errors that are made on these measures. The fact that previous studies suggest that NART performance is unimpaired in major depression provides support for this hypothesis. Crawford *et al.*, (1987) reported that there was no significant difference in NART performance between a sample of depressed patients and healthy matched controls despite impairment on WAIS vocabulary, while Austin *et al.* (1992) found similar results. These studies, however, looked at the performance of the NART in major depression without the co-occurrence of head-injury.

Finally, it may be that the association found between depression and years education is a spurious and random finding, one which would need to be confirmed through replication. Clearly, further research is required to determine which explanation is the most likely.

4.2.2 Comparison of Performance on Measures of Current Intellectual Functioning.

As noted in the introduction, the acute disruption of brain functioning frequently results in sudden impairments in intellectual capacities which can improve over a period of years (Mandelberg & Brooks, 1975). It was therefore expected that the head-injured group would perform significantly more poorly than controls on the measures of current intellectual functioning. Recovery on neuropsychological tests has been documented, however. Indeed, Lezak (1995) noted that many patients can perform adequately on conventional neuropsychological test batteries and stated that traumatically brain-injured adults have achieved score patterns on the WAIS that approximate the average. Yet intellectual impairment can persist in these patients and for this reason, the present study included measures of current intellectual functioning that were thought to be sensitive to the effects of cerebral dysfunction - the Stroop and Verbal Fluency tests - in addition to the WAIS-R.

The results of this study revealed that, even after controlling for the effects of years education, gender and depression, the head-injured subjects performed significantly more poorly on all the measures of current intellectual functioning, including the WAIS-R, Verbal Fluency, Stroop and MMSE, consistent with the experimental hypothesis. The head-injured group in the current study did not therefore attain an 'adequate performance' on the WAIS that has been previously documented in other studies.

4.2.3 Comparison of Performance between the Healthy and Orthopaedic Control Groups.

It is also interesting to note that the orthopaedic control group did not differ significantly from the normal control group on the measures of premorbid or current intellectual functioning. This gives credence to the view that any differences observed in the current study are due to the effects of the brain injury and are not due to the non-specific effects of trauma. If no orthopaedic control group had been adopted in the current study, it would be difficult to determine whether any differences shown by the head-injured group were the direct result of the effects of the injury on the brain or the psychological effects of the trauma itself.

4.2.4 Relationship between Premorbid Abilities and Head-Injury Severity.

Another method of examining the resistance of putative premorbid measures to cerebral dysfunction is to examine the correlation between these measures and measures of head-injury severity. O'Carroll & Gilleard (1986) adopted this approach in evaluating the NART's resistance to dementia and found that performance on this measure was largely dementia resistant. This approach was therefore adopted in the current study. Further evidence was provided that the NART, CCRT and Spot-the-Word have validity as a measure of premorbid IQ in head-injury as a result of the finding that the measure of the severity of head-injury sustained (Glasgow Coma Scale) was not correlated with performance on any of these premorbid measures. Had performance on these measures been compromised, a correlation between the measure of head-injury severity (GCS) and the premorbid measures would have been observed. This was clearly not the case. This finding suggests that the three tests 'hold' and are thus resistant to the effects of cerebral dysfunction following a closed head-injury.

4.2.5 Correlations between Premorbid and Current Intellectual Functioning.

To provide a valid estimate of premorbid intellectual levels, performance on present ability measures such as the NART, CCRT and Spot-the-Word must correlate highly with IQ in the normal population (Crawford, 1989). The results of this study demonstrated that the NART, CCRT and Spot the Word tests did significantly correlate with measures of current intellectual functioning - WAIS-R Full-Scale and Verbal IQ but not Performance IQ - in the healthy control group. Of all the premorbid measures, the CCRT was shown to be the most highly correlated measure with current intellectual functioning and was found to predict 38%, 67% and 5.4% of the variance in WAIS-R Full-Scale, Verbal and Performance IQ respectively. The NART was the next most highly correlated of the measures, predicting 32%, 62% and 3.4% of the variance in Full-Scale, Verbal and Performance IQ. The Spot-the-Word was found to have the weakest correlation and predicted only 24%, 41% and 3.5% of the variance in Full-Scale, Verbal and Performance IQ.

The finding that the CCRT is the most highly correlated measure with current intellectual functioning suggests that it is a reasonable predictor of IQ and provides evidence that it will provide a more accurate estimate of Full-Scale and Verbal IQ than the NART or the Spot-the-Word. Thus it would seem likely that the provision of contextual cues may have resulted in a score that was a more accurate reflection of IQ than the single-word reading test or lexical decision making test. On the basis of the correlational data alone, it is not possible to say how this has occurred. This issue will therefore be discussed further in the next section, when the differential performance of subjects on the CCRT and NART is examined. Preliminary evidence suggests, however, that the provision of context may be a useful modification which results in a more accurate estimate of Full-Scale and Verbal IQ, but is very poor at predicting Performance IQ.

This finding is consistent with that of Beardsall & Huppert (1997) who provided evidence that the CCRT is a valid measure of intelligence with the finding that it correlated with WAIS-R Verbal IQ. Regression equations built to examine the predictive ability of the CCRT revealed that it predicted 61% of the variance in WAIS Verbal IQ. The current study found that it predicted 67%. Different subtests may have been used to assess WAIS-R IQ which might account for the differences observed.

The results of this study also confirm the finding that the NART is highly correlated with intelligence in the normal population, although to a slightly lesser degree than the CCRT. This suggests that NART performance is a reasonable predictor of Full-Scale and Verbal IQ. It is not possible to directly compare the results with previous studies because the short-form WAIS-R was employed in this study (based on 4 subtests). In Nelson's original standardisation sample, the NART predicted 55%, 60% and 32% of the variance in WAIS Full-Scale, Verbal and Performance IQ respectively (based on 7 subtests), while Crawford *et al.*, (1989b) reported that NART performance predicted 66%, 72% and 33% of the variance in Full-Scale, Verbal and Performance IQ when the full WAIS was administered.

It must be noted, however, that a shrinkage in the amount of variance explained may be due to the use of a 4 subtest short-form rather than the full-WAIS. Further, the poor correlation that was demonstrated with Performance IQ may have resulted in a shrinkage in the predicted variance in Full-Scale IQ because of the fact that the final Full-Scale IQ score is composed of the Performance IQ as well as the Verbal IQ component.

As already indicated the Spot-the-Word was found to have the weakest correlations with current intellectual functioning (Full-Scale; r=.49: Verbal; r=.64). Although these relationships were found to be significant, the much lower predicted variance calls into question the ability of this test to predict premorbid WAIS-R IQ and raises doubts concerning its clinical utility in patients with cerebral dysfunction where the impact of erroneous estimates is likely to be great. These results are consistent with those of Law (1996), who found that the Spot-the-Word was not significantly correlated with any current measure of IQ (WAIS-R), but are not in keeping with the findings of Baddeley *et al.*, (1993) who found that performance on the Spot-the-Word correlated highly with verbal intelligence (r=.69). While this difference may be explained by the fact that Baddeley *et al.*, (1993) used the Mill Hill Vocabulary Test as a measure of verbal intelligence, it still signals caution in its use as a measure of premorbid abilities. As the Spot-the-Word test is based on lexical decision making, it may be that lexical decision making is not a skill which is as involved in the performance of tests of current cognitive functioning, hence the poorer correlation between the tests. Another hypothesis is that the lower correlations observed between the Spot-the-Word and WAIS-R IQ are due to the fact that many subjects were seen to guess their responses to the items they were unsure of in a random manner, with little conscious problem solving. This result may therefore be picking up the chance element in getting a word correct on the basis of guesswork and deflating the correlations.

The relationships between the premorbid tests themselves should also provide evidence for their validity as a measure of premorbid ability. The results in the current study have shown that the premorbid measures are all significantly correlated with each other in the healthy control group. The NART and CCRT were very highly correlated, and the Spot-the-Word was also highly correlated, although to a lesser degree with the NART and the CCRT. This suggests that the CCRT and the NART (not unsurprisingly given that the CCRT is a modification of the NART) are tapping into virtually the same capacities. This finding, however, provides some more evidence for the impact of context and thus the use of the CCRT over the NART. Although the NART and CCRT are measuring virtually the same capacities, the CCRT has been shown to predict more of the observed variance in current IQ than the NART, suggesting that it is the impact of context which is making this difference. The finding that the Spot-the-Word does not show such a close relationship to the other measures indicates that there is a difference in the capacities which are being measured. Again, this is not surprising given that the demands of the test are quite different from the NART and CCRT and that the test was originally designed to tap lexical decision making rather than reading ability. Such differences in capacities being measured is not necessarily a criticism of the Spot-the-Word if it were shown to measure a skill which would allow the accurate prediction of premorbid IQ, however, as previously indicated, this has not been found to be the case.

4.2.6 Comparison of Performance on the NART and CCRT.

One of the assumptions on which the NART is based is that subjects who do not pronounce the irregular NART words correctly have no prior knowledge of the word - or lexical entry - and this provides a reliable indicator of premorbid ability. This assumption was challenged by Beardsall & Huppert (1994) who hypothesised that mispronunciation may not necessarily indicate that the subject has no previous familiarity with the word, leading them to suppose that the NART would provide an underestimate of premorbid IQ if the method of presentation of the words did not allow access to a lexical entry. They suggested that the provision of contextual information would improve reading ability by allowing access to the lexical entry.

This assumption was also evaluated in the present study by comparing the reading ability of head-injured and control subjects on the traditional NART presentation with their performance on the CCRT - whereby the NART words were set within a semantic and syntactic context. The results indicated that head-injured and control subjects significantly improved their pronunciation performance on the CCRT in comparison to their performance on the NART. While the three groups in this study all showed improved performance on the CCRT, the head-injured group were found to benefit significantly more from the provision of contextual information than the healthy control group (average improvement of 4.64 words compared to 3.04 words respectively), although the magnitude of the improvement was not mediated by the severity of head-injury sustained. This finding suggests that reading ability is improved by context - resulting in a larger number of words being read correctly - and will therefore provide a more valid estimate of premorbid intelligence in closed head-injury.

The findings by Beardsall & Huppert (1994) and Law (1996) that the provision of contextual information resulted in improved reading ability in a sample of demented subjects and elderly controls, has therefore been replicated in a different clinical condition and in a younger control group. The results of this study therefore give credence to the hypothesis proposed by Beardsall & Huppert (1994) that mispronunciation of irregular NART words may not necessarily indicate that the subject has no previous familiarity with the word.

This study also demonstrated that subjects with average reading ability benefited significantly more from the inclusion of contextual cues than those with good reading ability, and this is again consistent with the findings of Beardsall & Huppert (1994). Average readers significantly improved their performance by an average of 4.00 words and 5.62 words in the healthy control and orthopaedic control groups respectively, while good readers improved their performance by an average of 2.33 words and 2.73 words in the respective control groups. It was not possible to comment on the poor readers as there was only one subject in each control group, so this would need further investigation. The results of this study did reveal, however, that good readers still significantly improved their pronunciation performance on the CCRT, unlike the previous research by Beardsall & Huppert (1994), who demonstrated only minimal benefit to good readers with context (0.6 words).

It would appear then, that by providing semantic and syntactic cues, the use of the CCRT results in an improvement in the number of words being read correctly by head-injured and control subjects. This suggests that it is a useful modification of the NART which will allow a more accurate and higher estimate of premorbid intellectual levels. It is important to consider why this may be the case and a number of explanations are possible.

One possibility is that subjects, rather than reading the words correctly, merely guess them correctly on the basis of the extra contextual information irrespective of whether they have a lexical entry, or prior knowledge, of the word. Beardsall & Huppert (1994) investigated this hypothesis by asking subjects to guess what the words may be after providing them with the context of the sentence but removing the irregular target words. A healthy control group was reported to find this task very difficult, producing very few correct guesses. In the light of this evidence, this possibility therefore seems unlikely.

Another possibility is that the improvement in word reading is a reflection of a practice effect since the NART was always presented prior to the CCRT. This would be expected if feedback were given to subjects about any incorrect responses, however this was not and is not given in the administration of the NART. Indeed, Beardsall & Huppert (1994) suggest that it would be very difficult to explain how pronouncing a word incorrectly on one occasion would prime its correct pronunciation on the next occasion. As Nelson & Willison (1991) state "the nature of the (NART) word makes it very unlikely that they would be affected by repetition" (p.17). More likely is the possibility that, if the CCRT were to be presented first, reading the words in a context would facilitate their correct pronunciation when subsequently provided in the single-word format.

Beardsall and Huppert (1994) have put forward another explanation as to why improved accuracy of pronunciation of NART words results from the provision of contextual information. It was suggested that words were in a subject's lexicon, and therefore familiar, if they correctly pronounced CCRT words that were mispronounced and by the NART. This was seen to be a consequence of contextual cues increasing the probability of recognising a target stimulus. As indicated above, the NART is assumed to reflect prior knowledge by virtue of the fact that subjects who do not pronounce the irregular NART words correctly have no prior knowledge of the word. Estimates of premorbid ability are then derived on the number of errors made. The findings of this study and those of Beardsall and Huppert (1994) suggests that the traditional NART format does not always allow subjects who have this knowledge to gain access to it - or recognise it as familiar - and consequently, they perform at a level which is unrepresentative of their 'true' prior knowledge. This calls into question the ability of the NART to provide a valid and accurate estimate of a subject's premorbid abilities because the range of prior knowledge tapped is only that which is accessed through single word reading. By providing the additional contextual information the CCRT allows subjects to gain access to their previously learned relevant stored knowledge, or activate the lexical entry, and thereby recognise words as familiar. In so doing, the CCRT allows subjects to perform at a level representative of their 'true' prior knowledge. It would appear then, that the CCRT facilitates the semantic route when reading irregular words although it is not clear whether this is the effect of the semantic or syntactic information or a combination of the two.

This explanation would also explain the differential benefit of the effect of context on good and average readers found in this study. If a stimulus is more familiar to a person, then it is unlikely that providing extra contextual information would influence its recognition by making it any 'more familiar'. As the good readers in this study had more education than the average readers (see Appendix 4) it seems likely that good readers were more familiar with many of the NART words. The omission of context when these words were presented in the traditional single word format would therefore have a lesser effect on their performance.

The educational background of the head-injured subjects was similar to that of the average readers and hence they benefited to the same degree from the provision of context. This would also explain why, overall, the head-injured subjects benefited more from the provision of context that the healthy control group, because, when looking at the group as a whole, the head-injured group were less educated than the healthy control group. The increase in the performance of the head-injured subjects on the CCRT is of particular interest as estimation of premorbid functioning needs to be as accurate as possible to aid in the evaluation of intellectual deterioration. It would appear that the improved performance of the head-injured group was by virtue of the fact that they were less educated than the healthy control group, and this is consistent with the comparable magnitude of change shown in average readers.

While the neuropsychological consequences of closed head-injury are highly varied depending on factors such as type, extent, location and acuteness of the damage, the results of this study are consistent with the observation that many patients with organic impairments such as head-injury, retain old, well-established verbal skills despite deterioration in memory, arithmetic ability, reasoning and other cognitive functions. It would appear that the CCRT facilitates the access of previously stored verbal knowledge in head-injury through the provision of context, thereby increasing the likelihood of a word being judged familiar. It would, however, be unrealistic to suppose that performance on any current ability measure would be entirely resistant to severe cerebral dysfunction and detailed investigations of head-injured subjects with differing types, extent, locations and acuteness of damage would be required to clarify the issues around why well-learned information appears to remain intact following closed head-injury.

4.2.7 Combining Premorbid Measures and Demographic Variables.

Given that performance on measures of premorbid intellectual functioning and demographic variables both correlate with current intellectual functioning, it has been proposed that combining the two approaches would result in a greater prediction of the variance in IQ than either method alone (Crawford *et al*, 1989e). This hypothesis was examined in the current study. It is important to peruse the results of the two methods alone, however, before scrutinising their combination. Although some evidence has been presented above regarding the relationship between measures of premorbid and current IQ (section 4.2.5), the comparison of the premorbid measures with the demographic methods alone still needs to be addressed. Thus, when examining each of the methods in isolation, the evidence presented in Table XII indicates that the CCRT is a more powerful predictor of Full-Scale and Verbal IQ test performance than demographic methods alone. The NART and demographic variables alone were shown to be very similar in the amounts of variance in Full-Scale and Verbal IQ. The Spot-the-Word, already found to be the worst single predictor of Full-Scale and Verbal IQ, did not even predict as much of the variance as the demographic method alone, which again calls into question the ability of this test to predict premorbid IQ. The appeal of the demographic approach has centred around its major advantage in that it provides an estimate of premorbid IQ that is totally independent of a patient's current cognitive functioning. No possibility exists, therefore, for the estimate to be subject to decline, unlike tests of current psychometric functioning (Crawford, 1992). A disadvantage of the approach, however, has rested on the fact that demographic equations explain less of the variance in measured intelligence. While this has certainly been shown to be the case in terms of the variance predicted by the CCRT, the demographic method has been shown to be an equivalent predictor to the NART and a better predictor that the Spot-the-Word. (Possible reasons for this were discussed in section 4.2.5.) This provides further evidence of the utility of the CCRT in providing a valid measure of premorbid intellectual functioning.

The results in this study indicate that the addition of demographic variables to the premorbid measures significantly increases the amount of explained variance in predicted WAIS-R Full-Scale and Verbal IQ, but not Performance IQ. This is consistent with other studies which have found the combination better than either method alone when this hypothesis was examined in relation to the NART in the UK (Crawford *et al,* 1989e; Crawford *et al.,* 1990f). It is interesting to note, however, that although five demographic variables were entered into the analysis, it was only one variable that significantly contributed to the amount of variance explained, the others becoming non-significant. Years of education was the demographic variable that significantly contributed to the variance in WAIS-R Full-Scale IQ, while social class significantly contributed to the variance in Verbal IQ. It is important to explain why this may be the case. These results would seem to indicate that there is a considerable proportion of shared variance between the demographic variables which relates to IQ, to the extent that only one variable mediates the relationship between the premorbid measures and predicted IQ. The others (such as age, sex and deprivation category) provided no additional information which contributed to the predicted variance in IQ. Indeed, it would be expected that years education and social class contain very similar information coded in different ways, so the reason why years education contributes more to Full-Scale IQ and social class to Verbal IQ is unclear. It may be that social class accounts for important differences in education not achieved by a measure of the amount alone.

The combination of the CCRT and demographic variables was the overall best predictor of Full-Scale and Verbal IQ in the healthy control sample in this study, predicting 43% and 73% of the variance in WAIS-R Full-Scale and Verbal IQ and 5% and 6% more of the respective variance than the equation based on the CCRT alone. The NART-demographic combination predicted slightly less of the variance - 38% and 69% in Full-Scale and Verbal IQ respectively - an increase of 6% and 7% over the NART alone. These increases are similar to those found by Crawford *et al,* (1989e) who demonstrated that the combined equations predicted 7% and 6% more of the variance in Full-Scale and Verbal IQ than the NART alone. The results of this study suggest that combining the variables does not have an additive effect on the proportion of IQ variance predicted because of the considerable shared variance between the premorbid measures and demographic variables, however a cumulative effect was also demonstrated. It is not possible to determine whether this result reflects the possibility that the unshared variance in the psychometric and demographic variables is still related to IQ, or whether the demographic variables are mediating the relationship between performance and IQ. The fact that the CCRT was shown to have a higher predictive accuracy than the other premorbid measures is an important determinant of estimating IQ from regression methods. The fact that the CCRT-demographic regression equation has high predictive accuracy indicates that it is less likely that marked discrepancies in favour of predicted over actual IQ will occur in the normal population and so finer discrimination between normal and impaired intellectual functioning can be achieved.

In the case of the Spot-the-Word regression equation, the demographic variables were found to contribute more of the variance in Full-Scale and Verbal IQ than the putative premorbid measure itself. The fact that the Spot-the-Word had a lower correlation with IQ than the demographic variables explains this phenomenon and also explains why it was that social class was entered in the first step in the regression equation as it accounted for more of the variance in IQ than the Spot-the-Word.

Finally, none of the premorbid measures were found to predict significant amounts of the variance in Performance IQ. This is in contrast to previous studies which report predictions of around 33% of the variance in Performance IQ from the NART alone and 39% when the NART was combined with demographic variables (Crawford *et al,* 1989e; Crawford *et al.,* 1990f). It is unlikely that tests of a verbal nature such as the NART, CCRT and Spot-the-Word would provide a good indicator of premorbid visuospatial abilities as measured by the Performance WAIS-R scale, however the fact that the current study demonstrated a much lower proportion of explained variance warrants explanation. The current study employed a 4 subtest short-form to determine Full-Scale, Verbal and Performance IQ based on two verbal and two visuospatial subtests. It seems likely that the tests used in the current study to measure Performance IQ - Block Design and Object Assembly - have very little verbal components to the task. Some of the other 'Performance' tests require verbal encoding and do therefore have a verbal component, for example the picture arrangement and picture completion subtests. The results demonstrated by Crawford et al (1989e) are based on the full WAIS and may therefore be picking up the verbal components in some of the 'Performance' subtests.

4.3. METHODOLOGICAL ISSUES.

4.3.1 Comment on Demographic Variables

The results in the current study revealed that the three subject groups were well matched in terms of age and maximal occupational history, but were not so in terms of years of education or sex differences. It should be noted, however, that the demographic characteristics of the head-injured group in the current study were fairly consistent with the literature documenting those most likely to suffer a head-injury i.e. predominantly young adult males. Further, the results of this study, whereby road traffic accidents were found to account for 52% of the cases of head-injury and assaults 32%, are remarkably consistent with the findings of Kraus *et al.*, (1984) who stated that road traffic accidents were found to account for approximately 50% of the cases of head injury, while assaults accounted for around 25-40%.

Another point worthy of note concerns how well the head-injured and orthopaedic control groups were matched. The head-injured group had a larger proportion of subjects who were involved in a road traffic accident (52%) than the orthopaedic control group (30%). Further, none of the orthopaedic group suffered an injury as the result of an assault - the largest proportion sustaining their injuries through sport (50%). While the two groups undoubtedly suffered some form of trauma, it would have been preferable if they were better matched in terms of the type of trauma sustained. The practicalities of this may be more difficult to achieve, however, as it seems likely that there are much less people who suffer orthopaedic injuries as a result of assaults. In addition, the orthopaedic sample in the current study were, in the main, composed of subjects who were in-patients and were therefore more likely to have been in an acute state. The head-injured group, on the other hand, were at least 9 months post-trauma. It would have been preferable if the groups were more comparable in terms of the duration since the injury was sustained. It may be that the head-injured group were significantly more depressed that the orthopaedic control group because they have had time to think through the implications of their loss and changes to their lives. Future research using an orthopaedic trauma control group would need to take these issues into consideration.

4.3.2 Other Methodological Problems

In addition to methodological issues already highlighted, several areas in this study warrant special attention. No attempt was made to control for the type and amount of medication subjects in the head-injured or orthopaedic samples were receiving, therefore there may have been confounding effects of differing treatment regimes. Further, the sample of individuals in the head-injured group were all drawn from a rehabilitation population. It may have been the case that the subjects in this group were pre-selected for rehabilitation by consultants on the basis that they would show greater improvements from the rehabilitation process - and which would explain the higher proportion of severely head-injured subjects in the current study.

Another point worthy of note is that the current study failed to address the issue of whether the location of damage to the brain had any bearing on the current findings. Typically, those who sustain a lesion in the left hemisphere have difficulties with verbal information while those with predominantly right hemisphere lesions have difficulties with visuospatial material. Further, as already indicated above, depression can result from disruption of the limbic system or structures it is linked with and it has also been suggested that left hemisphere lesions can provoke a 'major' depression (Gainotti, 1993). It would be interesting to tease out the effects of location of damage, to determine whether those with left hemisphere lesions performed more poorly than those who suffered from right hemisphere lesions and to examine the influence of hemispheric damage on emotional behaviour and performance on the premorbid measures. Indeed, there may have been differential performance within the head-injured group in the current study as a result of the site of injury sustained. It was not possible to examine this, however, as the information available in subjects' medical records was often incomplete or missing. Further, conventional brain imaging techniques such as the CT scan, which is typically used to determine the nature and extent of brain pathology, has been criticised on the ground that it only reveals gross underlying pathology and can fail to pick up subtle lesions.

Other methodological problems inherent in the study concern the assessment measures that were used. While every attempt was made to ensure that the testing session was as short as possible, it still took approximately 1 hour to complete the various tests. The number of assessments used may have caused fatigue, especially in the head-injured group who tend to be more susceptible to such effects. It is possible, therefore, that the finding that the head-injured group performed significantly more poorly than controls on the Verbal Fluency and Stroop tests is purely the result of fatigue. This is unlikely, however, given that this finding has been shown in other studies (e.g. Stuss, Ely & Hugenholtz, 1985; Miceli, Caltagirone & Gainotti, 1981) and also because the head-injured subjects performed significantly more poorly than controls on the WAIS-R which was administered earlier in the testing session. Future studies would need to take this issue into consideration by counterbalancing the presentation of assessments. Other methodological issues involving the assessments employed in the current study concerns the used of the Hospital Anxiety and Depression Scale (HAD). Although the HAD was designed in order to minimise the effects of concurrent physical illness on mood, certain statement may, in fact, tap into the effects of the head-injury rather than any mood disorder itself. For example, one statement subjects have to reply to states 'I feel as if I am slowed down.....' Another issue already touched on concerns the use of the short-form WAIS-R. Ideally, when using the WAIS-R, the full-length version should be employed, however, short-forms have been administered because of time constraints and the heavy caseloads in clinical work. Indeed, Crawford *et al.*, (1989b) reporting on the predictive ability of the NART, found an increase in the predicted variance in WAIS IQ which was attributed to the use of the full-length WAIS. It would therefore be useful to look at the relationship between the various measures of premorbid ability - especially the CCRT - with the full-length version of the WAIS-R to determine whether more of the variance in current IQ could be accounted for.

4.4 CONCLUSIONS AND FUTURE DIRECTIONS

Determining premorbid intellectual levels is of considerable importance in neuropsychological research and practice. As indicated in the introduction, any measure of current intellectual ability must satisfy three basic principles to be suitable as a valid method of estimating premorbid intelligence (Crawford, 1989), namely, it must correlate highly with intelligence in the normal population, it must be insensitive to cerebral dysfunction and it must have adequate reliability.

The finding that the CCRT is highly correlated with current intellectual functioning suggests that it is a reasonable predictor of IQ in the normal population and satisfies the first criteria necessary for it to qualify as a valid means of estimating premorbid abilities. The fact that it is more highly correlated with current intellectual functioning than the NART provides evidence that it will provide a more accurate estimate of Full-Scale and Verbal IQ than the single word reading test. This highlights the risk of NART predicted IQ scores underestimating premorbid ability in the clinical setting.

The improved performance on the Cambridge Contextual Reading Test as compared to the National Adult Reading Test suggests that the CCRT is a useful modification of the NART for estimating premorbid intellectual functioning in both head-injured and normal subjects. The greater improvement in performance on the CCRT compared to the NART in those subjects - head-injured or controls - that had completed fewer years education suggests that it may lead to quite different estimates of premorbid intellectual levels, with the CCRT providing a higher estimate of intelligence.

The other encouraging result reported in the current study is that the CCRT was found to be fairly resistant to the effects of neurological disorder sustained through a head-injury, thereby satisfying the second criteria necessary for it to qualify as a valid means of estimating premorbid abilities. This again provides evidence in support of this measure. While the NART was found to be resilient to the effects of head-injury, its inferior correlations with measures of current intelligence suggests that its use should be limited.

The issue of the reliability of the CCRT was not addressed in the present study and would obviously need to be examined through further research. Further, it is not currently possible to determine actual IQ scores from the number of CCRT errors. Beardsall & Huppert (1994) suggest that IQ scores can be derived from the number of CCRT errors using the NART conversion tables. It must be suggested, however, that this procedure is invalid because such equations have been derived as a result of the differing correlations between the NART and IQ and which may therefore lead to erroneous estimates of IQ. A larger scale study regressing the CCRT and WAIS-R is therefore required to enable the development of regression equations and thus easy conversion tables to determine IQ from the number of CCRT errors. It would also be of interest to carry out a factor analytic study of the WAIS-R and CCRT in an attempt to provide evidence of the construct validity of the CCRT as a measure of intelligence. Moreover, the concerns of Baddeley *et al.*, (1993), who argue that tests which require subjects to read aloud are unsuitable for patients who have dyslexia or who have visual acuity or articulatory problems, remain valid, and it continues to be a challenge to develop tests which can be used for those for whom the NART, and hence the CCRT, are inappropriate. Alternatively, clinicians will be forced to use demographic methods despite their lesser predictive ability and considerable band of error.

The current study found that the addition of demographic variables to the premorbid measures appears to increase the amount of variance in predicted IQ. While it is essential that any estimate of premorbid intellectual functioning is as accurate as possible, clinicians may feel that the slight gain in accuracy may not be justified by the additional effort that would be required in its computation.

Despite being found to be resistant to the effects of head-injury, the Spot-the-Word test was shown to be the weakest predictor of current IQ in the normal population which raises serious questions regarding its validity as a measure of premorbid intellectual functioning. Indeed it is less clear, therefore, precisely what capacities are being measured by this test.

On the basis of the above evidence and in addition to the findings already presented by Beardsall & Huppert (1994), the Cambridge Contextual Reading Test appears to provide a superior estimate of premorbid intellectual functioning and should therefore be the test of choice in estimating premorbid intelligence in a head-injured population. No precise method for estimating premorbid intellectual functioning exists and it is unrealistic to assume that any measure of current cognitive functioning will be totally resistant to the effects of cerebral dysfunction (O'Carroll, 1995). The key issue is in finding a method which is least affected by acquired cerebral dysfunction and which correlates the highest with intelligence in the general population. In the case of head-injury, the Cambridge Contextual Reading Test would appear to be this method.

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APPENDIX 1

DEMOGRAPHIC INFORMATION

Subject Number_______

Name	
Address	
Postcode:	
Sex:	**Male / Female**
Date of Birth:	**Age:**
Years Education	
Main Occupation	
Maximum Occupation	
Current Medication	
Glasses:	**Needed: Yes / No** **Wearing: Yes / No**
Head-Injured subjects:	
Dyslexia	**Yes / No**
Date/time since H.I.	
Cause of H.I.	
Severity of H.I.	
Orthopaedic subjects:	
Dyslexia?	**Yes / No**
Time since injury	
Cause of injury	
Previous H.I.?	**Yes / No**
Healthy control subjects:	
Dyslexia?	**Yes / No**
Previous H.I.?	**Yes / No**

SUMMARY OF RESULTS:

Visual Acuity Test	**OK / Reject**
NART Errors	**/50**
CCRT Errors	**/50**
Spot-the Word Errors	**/60**
WAIS-R: **Full-scale IQ** **Verbal IQ** **Performance IQ**	
MMSE	**/30**
Verbal Fluency	
Stroop	**/112**
HAD: **Anxiety** **Depression**	

National Adult Reading Test (NART)

SECOND EDITION

Word Card

Hazel E. Nelson

CHORD	SUPERFLUOUS
ACHE	SIMILE
DEPOT	BANAL
AISLE	QUADRUPED
BOUQUET	CELLIST
PSALM	FACADE
CAPON	ZEALOT
DENY	DRACHM
NAUSEA	AEON
DEBT	PLACEBO
COURTEOUS	ABSTEMIOUS
RAREFY	DETENTE
EQUIVOCAL	IDYLL
NAIVE	PUERPERAL
CATACOMB	AVER
GAOLED	GAUCHE
THYME	TOPIARY
HEIR	LEVIATHAN
RADIX	BEATIFY
ASSIGNATE	PRELATE
HIATUS	SIDEREAL
SUBTLE	DEMESNE
PROCREATE	SYNCOPE
GIST	LABILE
GOUGE	CAMPANILE

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National Adult Reading Test (NART)

SECOND EDITION

Answer/Record Sheet

Name:.. **Date of test:**..

	Errors		Errors
CHORD		SUPERFLUOUS	
ACHE		SIMILE	
DEPOT		BANAL	
AISLE		QUADRUPED	
BOUQUET		CELLIST	
PSALM		FACADE	
CAPON		ZEALOT	
DENY		DRACHM	
NAUSEA		AEON	
DEBT		PLACEBO	
COURTEOUS		ABSTEMIOUS	
RAREFY		DETENTE	
EQUIVOCAL		IDYLL	
NAIVE		PUERPERAL	
CATACOMB		AVER	
GAOLED		GAUCHE	
THYME		TOPIARY	
HEIR		LEVIATHAN	
RADIX		BEATIFY	
ASSIGNATE		PRELATE	
HIATUS		SIDEREAL	
SUBTLE		DEMESNE	
PROCREATE		SYNCOPE	
GIST		LABILE	
GOUGE		CAMPANILE	

Obtained WAIS/WAIS-R results*:

Full scale IQ [ ] Verbal IQ [ ] Performance IQ [ ]

NART error score [ ]

	Predicted IQ	Predicted-obtained IQ	Abnormality (%)
Full scale IQ			
Verbal IQ			
Performance IQ			

NART + Schonell error score [ ]

	Predicted IQ	Predicted-obtained IQ	Abnormality (%)
Full scale IQ			

*** Delete as appropriate**

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CAMBRIDGE CONTEXTUAL READING TEST - CCRT

SCORE SHEET

CCRT - PART A (Short CCRT) NART WORD	CORRECT/INCORRECT	CCRT - PART B NART WORD	CORRECT/INCORRECT
1. BOUQUET	....	13. SUPERFLUOUS	....
COURTEOUS	....	14. SIDEREAL	....
AISLE	....	SIMILE	....
CHORD	....	15. QUADRUPED	....
PSALM	....	16. CELLIST	....
PROCREATE	....	17. FACADE	....
2. DEPOT	....	DEMESNE	....
GOUGE	....	18. ZEALOT	....
3. CAPON	....	19. DRACHM	....
THYME	....	20. AEON	....
4. NAUSEA	....	21. PUERPERAL	....
ACHE	....	LABILE	....
5. HEIR	....	PLACEBO	....
DEBT	....	22. SYNCOPE	....
EQUIVOCAL	....	23. DETENTE	....
6. GAOLED	....	24. TOPIARY	....
DENY	....	IDYLL	....
7. SUBTLE	....	25. CAMPANILE	....
NAIVE	....	26. PRELATE	....
GIST	....	LEVIATHAN	....
8. RAREFY	....	27. GAUCHE	....
9. RADIX	....	BANAL	....
10. CATACOMB	....	28. AVER	....
11. HIATUS	....	29. ABSTEMIOUS	....
12. ASSIGNATE	....	30. BEATIFY	....
Number correct: ______			

TOTAL Number Correct (A+B) ______

CAMBRIDGE CONTEXTUAL READING TEST - CCRT

Lynn Beardsall and Felicia A Huppert

ASSESSOR'S COPY

CCRT - PART A (SHORT CCRT)

1. The bride was given a beautiful **bouquet** by the **courteous** groom. They began to walk down the **aisle** when the organist played the first **chord** of the **psalm**. Both the bride and groom came from large families, so, as soon as they were married, they were keen to **procreate** and have at least four children.

2. As the bus drove into the **depot**, it made a deep **gouge** along the side of a parked car.

3. The cook stuffed the **capon** with sage, lemon and **thyme**.

4. The pain in the girl's stomach gave her a feeling of **nausea**. She had a bad tummy **ache**.

5. The lawyer explained that the son who was **heir** to the estate had a large **debt** to pay, because his father's will was **equivocal**.

6. The prisoner was **gaoled** for five years, although he said, "I **deny** all of the charges against me."

7. The boy did not laugh at the joke. He missed the **subtle** meaning. He was so **naive** that he did not get the **gist** at all.

8. The scientist tried to **rarefy** the sample of gas.

9. The maths teacher explained to his pupils what a **radix** is.

10. The tourists went down the steps into the **catacomb** built under the church.

11. The plans for the new road had reached a dead end. It was hoped that this **hiatus** would be resolved by a public meeting.

12. The plain clothes policeman overheard the two youths **assignate** to meet behind the jewellers at midnight.

13. The farmer said, "I will sell the extra crops, because they are **superfluous** to our needs."

14. The poet described the cluster of diamonds in the ring as **sidereal**, using a **simile**.

15. A horse is a **quadruped**.

16. The concert was given by a famous **cellist**.

17. As they looked at the front of Buckingham Palace, the tourists admired its **facade**. The guide explained that the palace was part of Queen Elizabeth's **demesne**.

18. The terrorist who planted the bomb was a **zealot**.

19. The currency in ancient Greece was the **drachm**.

20. The newly discovered star may have existed for an **aeon**.

21. The doctor advised the pregnant woman to take plenty of rest during the **puerperal** period. He explained it is a time when women's moods may be **labile**. Rather than give her a drug which might affect the baby, he decided it would be safer to give her a **placebo**.

22. In the Russian language, letters are sometimes omitted from words according to the **syncope** rules.

23. The peace talks led to **detente** between Russia and the West.

24. The gardener's particular interest was **topiary**. His garden was an **idyll**.

25. In Italy, many churches have a separate **campanile**.

26. Towards the end of the church service, the **prelate** told the little children the story about the **leviathan**.

27. The young man's efforts to woo the girl were rather **gauche**. His wooings sounded **banal** rather than romantic as he intended.

28. When there is controversy, what one expert denies upon the subject, another will **aver**.

29. At the banquet where the food was very rich and the wines of a fine vintage, the major was most **abstemious**.

30. The Pope held a special service to **beatify** the saint.

CCRT - PART A

1. The bride was given a beautiful bouquet by the courteous groom. They began to walk down the aisle when the organist played the first chord of the psalm. Both the bride and groom came from large families, so, as soon as they were married, they were keen to procreate and have at least four children.

2. As the bus drove into the depot, it made a deep gouge along the side of a parked car.

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. At the banquet where the food was very rich and the wines of a fine vintage, the major was most abstemious.

. The Pope held a special service to beatify the saint.

The Spot-the-Word Test   Version A

This is a test of your knowledge of words. You will be asked to decide which of two items, such as 'bread' and 'glot', is a real word and which is an invented item; 'bread', of course, is the real word.

Each of the pairs of items below contains one real word and one nonsense word, invented so as to look like a word but having no meaning. Please tick the item in each pair that you think is the real word. Some will be common words, most will be uncommon and some very rarely used. If you are unsure, guess, you will probably be right more often than you think.

Before you begin the main test try the following.

Practice

kitchen	–	harrick
puma	–	laptess
plorinum	–	levity
cuticle	–	andrinand
flonty	–	xylophone
craxent	–	sofa

Are there any questions?

broxic	–	oasis
pinnace	–	strummage
mannerism	–	whitten
daffodil	–	gombie
bellissary	–	cyan
vellicle	–	sampler
necromancy	–	ghoumic
narwhal	–	epilair
venady	–	monad
plargen	–	savage
clegger	–	minim
knibbet	–	mandrake
canticle	–	grammule
threnody	–	epigrot
brastome	–	banshee
shako	–	strubbage
paraclete	–	elezone
froopid	–	clod
rouse	–	choffid
goblet	–	prelly
flexipore	–	viscera
agipect	–	almond
tarantula	–	hostent
trelding	–	rafters
legify	–	archaic
obsidian	–	plassious
restance	–	zombie
pimple	–	brizzler
frellid	–	static
hilfren	–	domain

livid	–	trasket
thrash	–	listid
holomator	–	dross
orifice	–	serple
phalanx	–	distruvial
chloroleptic	–	lapidary
biothon	–	palfrey
archipelago	–	zampium
groudy	–	toga
moxid	–	tangible
moralist	–	florrical
quince	–	bostry
lignovate	–	epicene
gibbon	–	wonnage
hipple	–	osprey
element	–	pargler
viridian	–	psynoptic
glorvant	–	onyx
plankton	–	whippen
akimbo	–	periasty
centaur	–	tritonial
vinady	–	bargain
prinodal	–	mango
reticule	–	fluxent
frembulous	–	ontology
loxeme	–	legerdemain
hoyden	–	clinotide
aboriginal	–	hostasis
clavanome	–	bestiary
zando	–	albatross

WAIS-R UK

RECORD FORM

ECHSLER ADULT
TELLIGENCE SCALE—
EVISED

RITISH ADAPTATION

NAME ______________________

ADDRESS ______________________

SEX ________ AGE ________ MARITAL STATUS ________

CCUPATION ______________________ EDUCATION ______________________

UNTRY OF BIRTH ______________________ FIRST LANGUAGE ______________________

ACE OF TESTING ______________________ TESTED BY ______________________

HER INFORMATION ______________________

____

____

____

TABLE OF SCALED SCORE EQUIVALENTS*

Scaled Score	RAW SCORE											Scaled Score
	VERBAL TESTS						PERFORMANCE TESTS					
	Information	Digit Span	Vocabulary	Arithmetic	Comprehension	Similarities	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Digit Symbol	
19	—	28	70	—	32	—	—	—	51	—	93	19
18	29	27	69	—	31	28	—	—	—	41	91-92	18
17	—	26	68	19	—	—	20	20	50	—	89-90	17
16	28	25	66-67	—	30	27	—	—	49	40	84-88	16
15	27	24	65	18	29	26	—	19	47-48	39	79-83	15
14	26	22-23	63-64	17	27-28	25	19	—	44-46	38	75-78	14
13	25	20-21	60-62	16	26	24	—	18	42-43	37	70-74	13
12	23-24	18-19	55-59	15	25	23	18	17	38-41	35-36	66-69	12
11	22	17	52-54	13-14	23-24	22	17	15-16	35-37	34	62-65	11
10	19-21	15-16	47-51	12	21-22	20-21	16	14	31-34	32-33	57-61	10
9	17-18	14	43-46	11	19-20	18-19	15	13	27-30	30-31	53-56	9
8	15-16	12-13	37-42	10	17-18	16-17	14	11-12	23-26	28-29	48-52	8
7	13-14	11	29-36	8-9	14-16	14-15	13	8-10	20-22	24-27	44-47	7
6	9-12	9-10	20-28	6-7	11-13	11-13	11-12	5-7	14-19	21-23	37-43	6
5	6-8	8	14-19	5	8-10	7-10	8-10	3-4	8-13	16-20	30-36	5
4	5	7	11-13	4	6-7	5-6	5-7	2	3-7	13-15	23-29	4
3	4	6	9-10	3	4-5	2-4	3-4	—	2	9-12	16-22	3
2	3	3-5	6-8	1-2	2-3	1	2	1	1	6-8	8-15	2
1	0-2	0-2	0-5	0	0-1	0	0-1	0	0	0-5	0-7	1

inicians who wish to draw a profile may do so by locating the subject's raw scores on the table above and draw- a line to connect them. See Chapter 4 in the Manual for a discussion of the significance of differences between res on the tests.

	Year	Month	Day
Date Tested	____	____	____
Date of Birth	____	____	____
Age	____	____	____

SUMMARY

	Raw Score	Scaled Score
VERBAL TESTS		
Information	____	____
Digit Span	____	____
Vocabulary	____	____
Arithmetic	____	____
Comprehension	____	____
Similarities	____	____
Verbal Score		____
PERFORMANCE TESTS		
Picture Completion	____	____
Picture Arrangement	____	____
Block Design	____	____
Object Assembly	____	____
Digit Symbol	____	____
Performance Score		____

	Sum of Scaled Scores	IQ
VERBAL	____	____
PERFORMANCE	____	____
FULL SCALE	____	____

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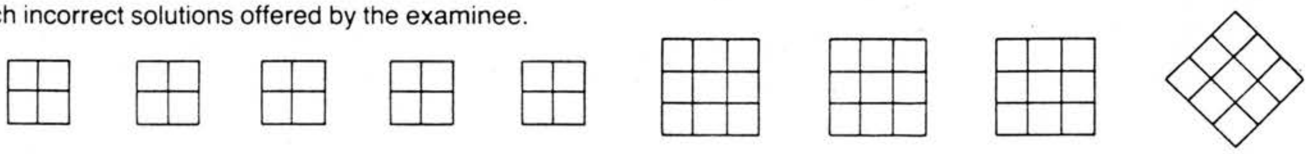
5 6 7 8 9 0

6 BLOCK DESIGN **Discontinue after 3 consecutive failures.**

Design		Time	Pass-Fail	Score (Circle the appropriate score for each design.)
1	60″	1		2
		2		0 1
2	60″	1		2
		2		0 1
3	60″			16-60 11-15 1-10 0 4 5 6
4	60″			16-60 11-15 1-10 0 4 5 6
5	60″			21-60 16-20 11-15 1-10 0 4 5 6 7
6	120″			36-120 26-35 21-25 1-20 0 4 5 6 7
7	120″			61-120 46-60 31-45 1-30 0 4 5 6 7
8	120″			76-120 56-75 41-55 1-40 0 4 5 6 7
9	120″			76-120 56-75 41-55 1-40 0 4 5 6 7
			Total	**Max = 51**

Correct solutions

Sketch incorrect solutions offered by the examinee.



Notes:

7 ARITHMETIC **Discontinue after 4 consecutive failures.**

Problem		Response	Score 1 or 0
1	15″		
2	15″		
3	15″		
4	15″		
5	30″		
6	30″		
7	30″		
8	30″		
9	30″		

Problem		Response	Time	Score (Circle)
10	60″			11-60 1-10 0 1 2
11	60″			11-60 1-10 0 1 2
12	60″			11-60 1-10 0 1 2
13	60″			16-60 1-15 0 1 2
14	120″			16-120 1-15 0 1 2
			Total	**Max = 19**

Note: Be sure to include scores for items 1-9 in Total.

9 **COMPREHENSION** **Discontinue after 4 consecutive failures.**	**Score 2, 1, or 0**
1 Clothes	
2 Envelope	
*3 Foods	
*4 Child employment	
5 Deaf	
6 Borrow	
7 Cinema	
8 Marriage	
9 Tax	
10 Forest	
11 Prescription	
12 Iron	
13 Land	
14 Waters	
15 Swallow	
16 Press	
*If the subject replies with only one idea, ask for a second response. Rephrase the test item appropriately, saying, '**Tell me another reason why...** ***Total***	**Max=32**

Notes on the subject's performance of particular test items, unusual behaviour, or special conditions which may have influenced the results can be recorded below.

Test	Item No.	Notes

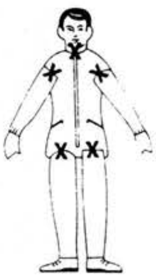
8 OBJECT ASSEMBLY **Give entire test to all subjects.**

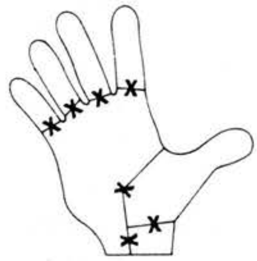
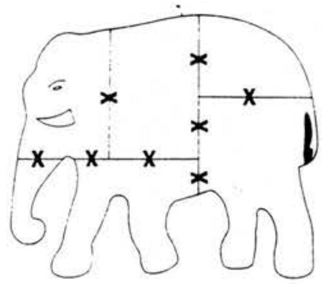
Object		Time	Score (Circle appropriate score for each object.)													
1 Manikin	120″		0	1	2	3	4	21-120 5	16-20 6	11-15 7	1-10 8					perfect assembly
2 Profile	120″		0	1	2	3	4	5	6	7	8	36-120 9	26-35 10	21-25 11	1-20 12	perfect assembly
3 Hand	180″		0	1	2	3	4	5	6	51-180 7	36-50 8	26-35 9	1-25 10			perfect assembly
4 Elephant	180″		0	1	2	3	4	5	6	7	51-180 8	31-50 9	21-30 10	1-20 11		perfect assembly

Max = 41

Total

Object Assembly: For incomplete solutions, circle each X representing a connection for which the examinee receives credit.



Notes:

Notes on the subject's performance of particular test items, unusual behaviour, or special conditions which may have influenced the results can be recorded below.

Test	Item No.	Notes

10 DIGIT SYMBOL

1	2	3	4	5	6	7	8	9
—	⊥	⊐	L	⊔	O	∧	X	=

SCORE

SAMPLES

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

11 SIMILARITIES **Discontinue after 4 consecutive failures.**	**Score 2, 1, or 0**
1 Orange–banana	
2 Dog–lion	
3 Coat–suit	
4 Boat–car	
5 Eye–ear	
6 Button–zip	
7 North–west	
8 Egg–seed	
9 Table–chair	
10 Air–water	
11 Poem–statue	
12 Work–play	
13 Fly–tree	
14 Praise–punishment	
	Max = 28
Total	

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MINI-MENTAL STATE

NAME: ______________________ AGE: ______ UNIT NUMBER: ______

EXAMINED BY: ______________________ DATE: ______

Maximum Score	Score	
		ORIENTATION
5	( )	What is the (year) (season) (date) (day) (month)
5	( )	Where are we (country) (county) (nearest large town) (hospital (villa/unit)
		NEW LEARNING
3	( )	Name 3 objects: 1 second to say each. Then ask the patient to say all 3. Give 1 point for each correct answer. Then repeat them until patient learns all 3. Count trials and record. No. of trials:
		ATTENTION AND CALCULATION
5	( )	Serial 7's. 1 point for each correct. Stop after 5 answers *or* spell "world" backwards.
		RECALL
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct.
		LANGUAGE
9	( )	Name a pencil and watch (2 points) Repeat the following "No ifs, ands or buts" (1 point) Follow a three stage command: "Take a piece of paper in your right hand, fold it in half and put it on the floor". (3 points) Read and obey the following: CLOSE YOUR EYES (1 point) Write a sentence (1 point) Copy design (1 point)

______ TOTAL SCORE

ASSESS level of consciousness along this line:

ALERT DROWSY STUPOR COMA

Controlled Word Association Test (Benton, 1973)

Name: **Date:**

F **A** **S**

Sub-total: **Correction:** **Total:** **Percentile:**

STROOP

Neuropsychological Screening Test

RECORD FORM

Max R. Trenerry, Ph.D.
Bruce Crosson, Ph.D.
James DeBoe, Ph.D.
William R. Leber, Ph.D.

Name ______________________________

Sex __________ Age __________ Date ______________________

Reason for Referral ______________________________

Diagnosis/Notes ______________________________

____

____

SCORES

	Color Task	Color-Word Task
Number of Responses	______	______
Incorrect Responses	______	______
Score	______	______
Percentile		______
Pr (Brain Damage)		______

PAR Psychological Assessment Resources, Inc./P.O. Box 998/Odessa, FL 33556/TOLL-FREE 1-800-331-TEST

9 8 7

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Form C-W Responses – Color-Word Task

1 RED________
2 BLUE________
3 GREEN______
4 BLUE________
5 RED________
6 TAN________
7 BLUE________
8 RED________
9 TAN________
10 GREEN______
11 BLUE________
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16 RED________
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105 RED________
106 TAN________
107 BLUE________
108 TAN________
109 RED________
110 BLUE________
111 GREEN______
112 TAN________

HAD Scale

Name: Date:

Doctors are aware that emotions play an important part in most illnesses. If your doctor knows about these feelings he will be able to help you more.
This questionnaire is designed to help your doctor to know how you feel. Read each item and place a firm tick in the box opposite the reply which comes closest to how you have been feeling in the past week.
Don't take too long over your replies: your immediate reaction to each item will probably be more accurate than a long thought-out response.

Tick only one box in each section

I feel tense or 'wound up':
- Most of the time ....
- A lot of the time ....
- Time to time, Occasionally ....
- Not at all ....

I still enjoy the things I used to enjoy:
- Definitely as much ....
- Not quite so much ....
- Only a little ....
- Hardly at all ....

I get a sort of frightened feeling as if something awful is about to happen:
- Very definitely and quite badly ....
- Yes, but not too badly ....
- A little, but it doesn't worry me ....
- Not at all ....

I can laugh and see the funny side of things:
- As much as I always could ....
- Not quite so much now ....
- Definitely not so much now ....
- Not at all ....

Worrying thoughts go through my mind:
- A great deal of the time ....
- A lot of the time ....
- From time to time but not too often ...
- Only occasionally ....

I feel cheerful:
- Not at all ....
- Not often ....
- Sometimes ....
- Most of the time ....

I can sit at ease and feel relaxed:
- Definitely ....
- Usually ....
- Not often ....
- Not at all ....

I feel as if I am slowed down:
- Nearly all the time ....
- Very often ....
- Sometimes ....
- Not at all ....

I get a sort of frightened feeling like 'butterflies' in the stomach:
- Not at all ....
- Occasionally ....
- Quite often ....
- Very often ....

I have lost interest in my appearance:
- Definitely ....
- I don't take so much care as I should.....
- I may not take quite as much care ....
- I take just as much care as ever ....

I feel restless as if I have to be on the move:
- Very much indeed ....
- Quite a lot ....
- Not very much ....
- Not at all ....

I look forward with enjoyment to things:
- As much as ever I did ....
- Rather less than I used to ....
- Definitely less than I used to ....
- Hardly at all ....

I get sudden feelings of panic:
- Very often indeed ....
- Quite often ....
- Not very often ....
- Not at all ....

I can enjoy a good book or radio or TV programme:
- Often ....
- Sometimes ....
- Not often ....
- Very seldom ....

Do not write below this line

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2363UK

Appendix 2

NORMAL DISTRIBUTION DATA

To ascertain whether parametric statistics could be employed to analyse the data, the Kolmogorov-Smirnov Goodness of Fit Test was used to determine whether the measures differed significantly from the normal distribution. A significant result indicates that the data are not normally distributed, that is, the data differed significantly from the normal distribution. The results are shown below:

	Kolmogorov-Smirnov Z statistic	***Significance Level (p=)***
Premorbid Measures:		
NART errors	.8241	p=.5054 (NS)
CCRT errors	.6244	p=.8304 (NS)
S-t-W errors	.9420	p=.3375 (NS)
Current Measures:		
WAIS-R:		
FSIQ	.5916	p=.8751 (NS)
VIQ	1.2337	p=.0953 (NS)
PIQ	.8319	p=.4932 (NS)
MMSE	2.7148	p<.001
V.Fluency	.5524	p=.9204 (NS)
Stroop	2.265	p<.001
Psychological Distress:		
Anxiety	1.0953	p=.1814 (NS)
Depression	1.5732	p<.05
Demographic Details:		
Age	1.6413	p<.01
Years Education	1.0702	p=.2022 (NS)

The Levene Test for Homogeneity of Variance was used to determine whether the measures came from populations with the same shared variance. A non-significant result indicates that the group variances are not significantly different. The results are shown below:

	Levene F statistic	***Significance Level (p=)***
Premorbid Measures:		
NART errors	.2381	p=.789 (NS)
CCRT errors	.2717	p=.763 (NS)
S-t-W errors	.8021	p=.451 (NS)
Current Measures:		
WAIS-R:		
FSIQ	1.2717	p=.285 (NS)
VIQ	1.5827	p=.211 (NS)
PIQ	1.0447	p=.356 (NS)
MMSE	16.5544	p<.001
V.Fluency	.0145	p=.986 (NS)
Stroop	11.3232	p<.001
Psychological Distress:		
Anxiety	5.3059	p<.01
Depression	9.4877	p<.001
Demographic Details:		
Age	.5727	p=.566 (NS)
Years Education	2.6184	p=.078 (NS)

APPENDIX 3

Relationship between Depression and the Measures of Premorbid and Current Intellectual Functioning controlling for Years Education (Pearson correlation coefficient [r] and two-tailed significance, n=95).

	Depression
NART Errors	.1387 p=.183 (NS)
CCRT Errors	.1736 p=.094 (NS)
S-t-W Errors	.1710 p=.099 (NS)
WAIS-R FSIQ	-.2461 p<.05
WAIS-R VIQ	-.1310 p=.208 (NS)
WAIS-R PIQ	-.2613 p<.05
MMSE	-.2832 p<.01
Verbal Fluency	-.1893 p=.068 (NS)
Stroop	-.2876 p<.01

APPENDIX 4

Information on years of education for each subgroup - Mean and (Standard deviation).

	Years of Education
Normal Controls:	
Good readers (n=30)	**15.54** (2.55)
Average readers (n=19)	**13.43** (1.30)
Poor readers (n=1)	**12.00**
Total	**14.67** (2.38)
Head-Injured	
Mild (n=4)	**12.06** (1.96)
Moderate (n=6)	**11.46** (0.51)
Severe (n=15)	**12.02** (1.80)
Total	**11.89** (1.58)
Orthopaedic Controls	
Good readers (n=11)	**13.59** (2.13)
Average readers (n=8)	**12.00** (2.83)
Poor readers (n=1)	**11.00**
Total	**12.82** (2.48)